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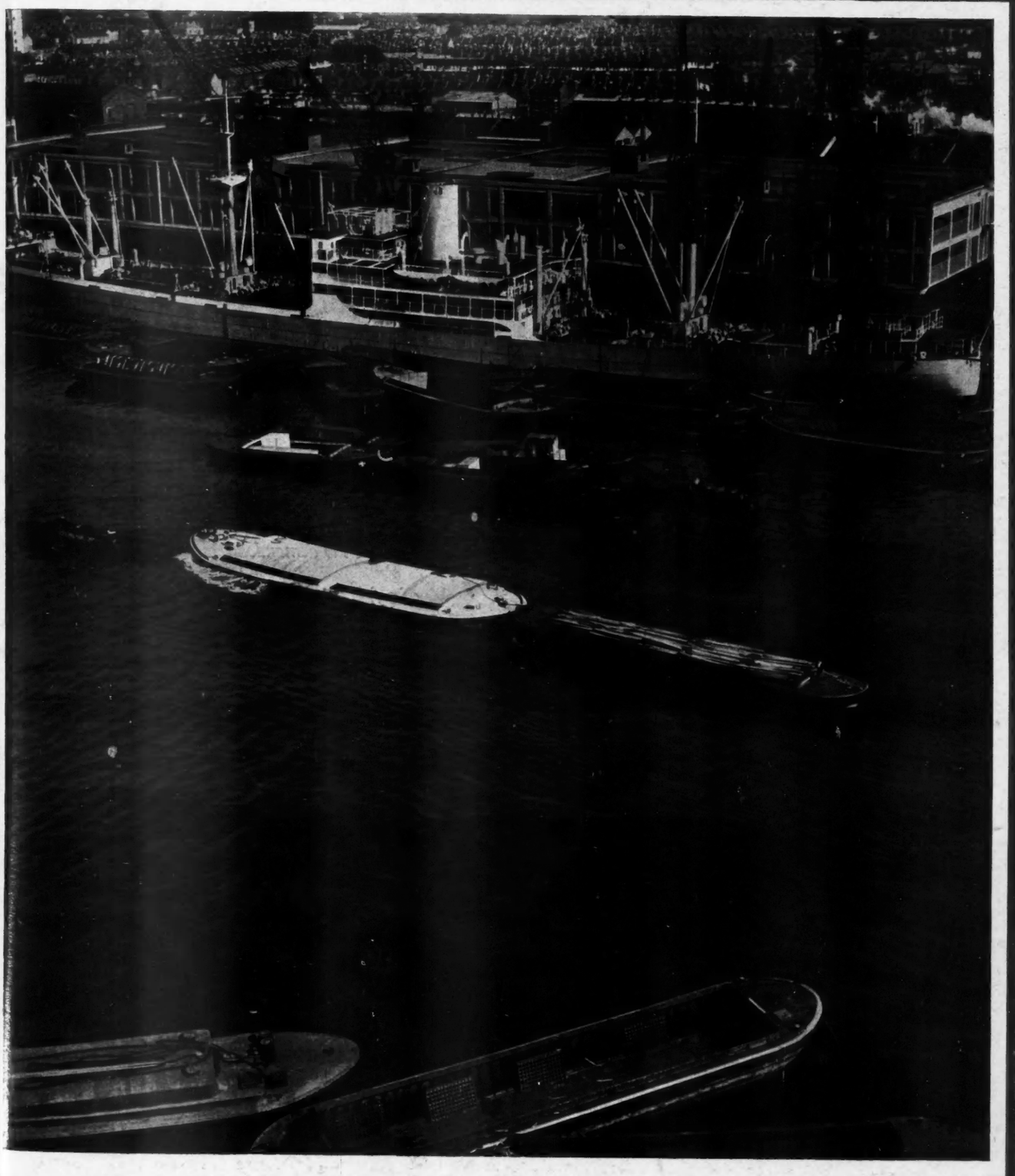

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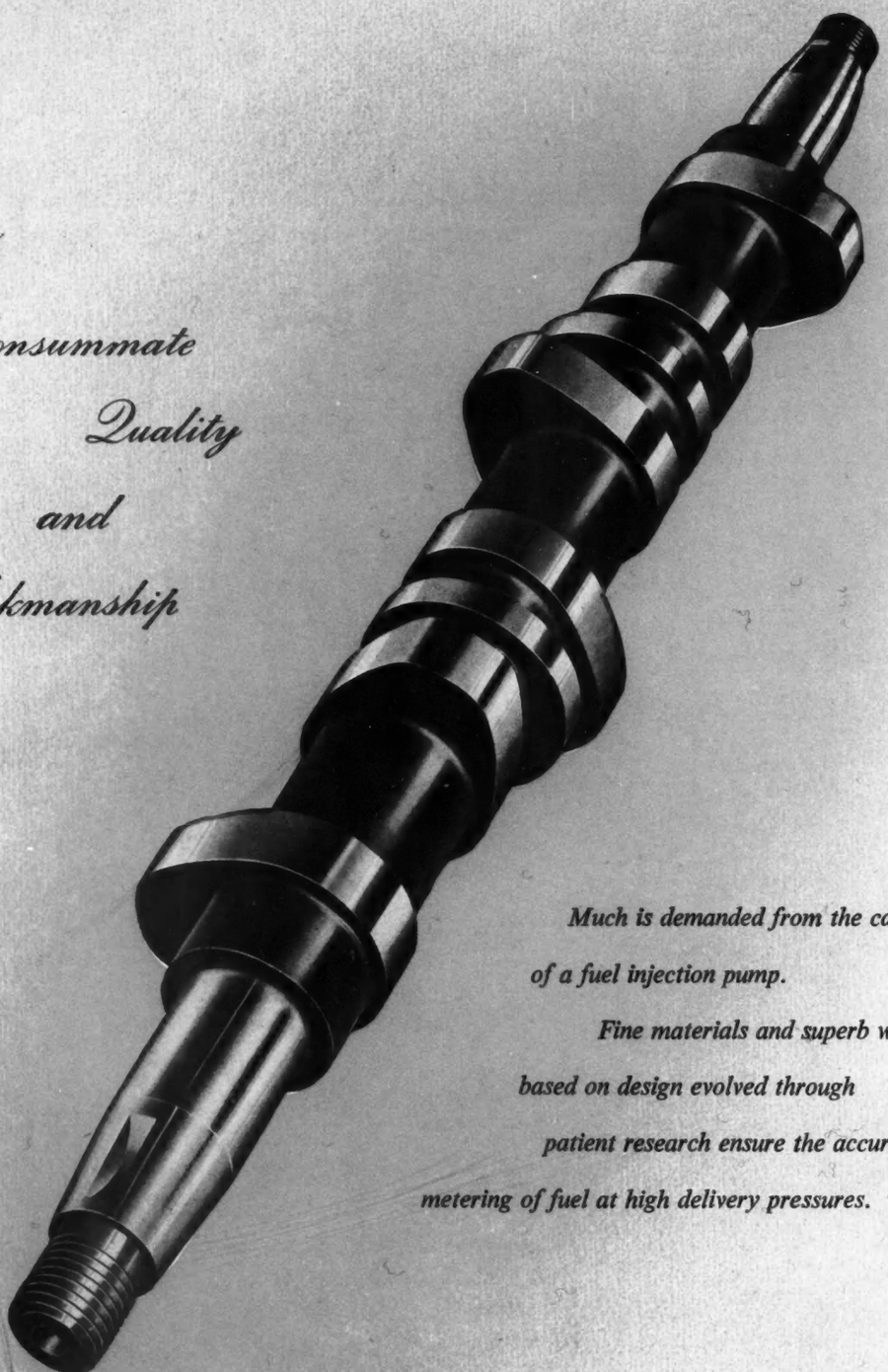

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DRAUGHTSMEN

It would be difficult to over-estimate the importance of draughtsmen. Yet of all the professions and crafts which constitute the engineering industry they are frequently the least well directed. They work at the focal point of all departments—market research, sales, accountancy, purchasing, research, production, distribution—but it is difficult to ensure that their designs reflect the needs and capabilities of those departments appropriately and economically. The key position which draughtsmen occupy is perhaps the reason for this difficulty.

Good design is the product of experience, knowledge and information—the experience of past design, the knowledge of theory and practice, and the information communicated to the designer by other departments. The experience required is not necessarily long specialisation in one branch of engineering, for that kind of experience can easily lead to a conservative approach, an inability to see new possibilities. It is far better to have had just that variety of work in the past which is needed to maintain a questioning mind.

Knowledge of theory and practice, of design and production, is cumulative, built up by the individual from a hundred sources. He may not remember all the detail, but he knows where to find it—in reference books, text-books and the technical journals which he reads and scans week by week. Information communicated to him by other departments is less under his control; at the worst it is fortuitous, at the best it is organised by overall direction. In rare cases the draughtsman may be able to work reasonably successfully without contact outside the drawing office, but in the majority of engineering organisations it is vital to establish a two-way flow of information if the best results are to be achieved.

The draughtsman's job is to co-ordinate these three sources of data—his own experience, his available knowledge, and information derived from others. When he designs he commits to the drawing board the result of his co-ordination. If any of the three sources is weak the design will eventually reveal that weakness, but the revelation may come long after the product is in service, when it is too late or costly to rectify the fault.

Assuming the right conditions to have been created, what is expected of the draughtsman in return? Apart from the obvious requirements there is one faculty which is all too rare, namely, the ability to conceive a design spatially rather than orthogonally. The conventional method of engineering drawing is a convenient technique for conveying the designer's intentions to the production department, but the designer should not think in terms of plan and elevation in the earlier stages of his work. If he does, his design will be a "three-directional" conception; its components, centre lines, etc., will be in three planes at right-angles to each other (or in planes parallel to those three), whereas the optimum design probably requires that certain parts shall be at various angles, or of non-geometric shape. This distinction is readily seen by comparing a prototype with a later more highly-developed model. Compare, for example, the angular, four-square construction of a First World War tank and the developed shape of a modern tank. Or compare the subtle form of a wooden wheelbarrow, every member at a peculiar angle (for a good purpose), with the rectangular construction that a designer would produce if he had never seen a wheelbarrow and were given only a general specification. The good designer is one who can cut out as much as possible of the development stages before he transfers his ideas to the finished drawing. Plan and elevation are his ultimate method of expression, not the first instruments of his conception.

Small wonder that there is always a shortage of good draughtsmen! The work demands exceptional qualities and it demands variety of experience. That variety can only be gained if the man himself and his employers are willing to arrange for it. Change of work, within one firm, might reduce the frequency with which draughtsmen leave to take up posts with other firms. In the long run it would prove to be an advantage to the firm because it would encourage a cross-fertilisation of ideas, it would stimulate that keen interest in their work which is natural to draughtsmen, and it would thereby expedite development work which at the present time is being retarded by the shortage of draughtsmen. The Manchester Joint Research Council's report "Industry and Science" suggested that the shortage will not be rectified until more young men can be influenced to enter industry through the drawing office. This is a very doubtful proposition, at least in the engineering industry. A draughtsman without practical experience in the shops can be a very expensive member of the staff. But indirectly perhaps the Council have touched on the important points: what is the best preparatory training for the drawing office? Is there any generally accepted route? Did present-day draughtsmen originally set out to be draughtsmen, or have they simply arrived in the D.O. by chance? A national policy which could give satisfactory answers to these questions would go a long way towards giving draughtsmen their proper status.

Weekly Survey

ELECTRICITY SUPPLY

The sixth annual report and statement of accounts of the British Electricity Authority for the year ended March 31, 1954 (H.M. Stationery Office, price 9*s*.) contains a mass of technical and other information regarding the progress of an important national industry. The results as set out need engender no pessimism, although it is clear that many difficult problems still have to be faced. The position with regard to generating plant may now be regarded as moderately satisfactory, although the margin is described as still precariously narrow. At the end of the period under review the installed capacity was nearly 18,650 MW, of which 1,420 MW were added during the year. Allowing for the removal of some unserviceable or obsolete plant, the net increase was 1,370 MW. Eight new stations, with an aggregate capacity of 415 MW, were brought into operation. It is hoped that a further 8,600 MW will be added by the end of 1959.

This progress, it is satisfactory to note, is being accompanied by advances in design. While 30-MW and 60-MW sets have been " standard " in recent years, in five years time four 100-MW., five 120-MW and one 200-MW sets should have been commissioned. The last of these will be designed to operate at a pressure of 2,350 lb. per square inch and a temperature of 1,050 deg. F., a notable breakaway from existing practice. It is equally satisfactory to note that the overall thermal efficiency of the plant in operation rose during the year under review to 23·4 per cent., thus effecting a considerable saving in fuel consumption. This is shown by the fact that while the electricity generated rose from 61,603 million kWh in 1952-53 to 66,107 million kWh in 1953-54, an increase of 7·3 per cent., the corresponding increase in the coal consumption was only 4·3 per cent. Such a result is economically important, since fuel prices rose by 6 per cent. The maximum potential demand during the year was 14,850 MW and would have been higher by 879 MW had not the frequency and voltage been reduced. On the other hand, there was only one power cut, compared with 79 in 1951-52.

The route mileage of the grid is now 5,155 miles, of which 41 miles are operated at 275 kV, 4,615 miles at 132 kV and the remainder at lower voltages. The number of consumers exceeded 14,380,000, an increase of 529,685 during the year, while the number of farms connected was 152,507, an increase of 12,948. Attention is called to an extensive programme of rural development which should enable some 105,000 farms, as well as numerous rural houses and premises, to receive a supply during the next ten years. At the other end of the scale the hope is expressed that it will be possible to undertake the building of base-load nuclear power stations as part of the Authority's normal activities. Wisely, however, no date for this development is given.

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NOT ENOUGH COAL

It has been apparent for some months that only a major effort from the coal miners or an improvement in the British weather—matters which seem to be equally difficult to forecast—could improve the worsening coal supply situation this year. The holiday season is almost over and the miners may be expected to begin their annual spurt shortly, which will build up until just before Christmas.

Coal output to date is about 157 million tons compared with 156 million tons for the same period of 1953. There has been a slight increase in the output of deep-mined coal, but open-cast coal production has fallen off. It is on the side of consumption, however, that there has been a notable change. Coal consumption in the first 36 weeks of this year was 157 million tons compared with more than 152 million tons in the same period of last year. Thus consumption has increased by about 4 million tons while output has gone up by only one 1 million tons. The industrial boom of 1954 has been bought, it would seem, at a dear price in terms of coal. At the middle of September, 1953, coal stocks stood at 16,957,000 tons; on September 11 this year they were only 15,448,000 tons. Thus, with industry continuing to make heavy demands on coal supplies especially in the form of electric power, and the stock-building season nearly at an end, the economy is about 1½ million tons of coal short of the level reached at this time last year. The continued importation of coal will help to alleviate the situation to a limited extent, but the avoidance of a coal crisis in February or March next year still depends on those two unpredictable factors, the miners and the weather.

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OIL OR COAL FOR MARGINAL SUPPLIES?

An interesting and controversial report has been issued by the Economic Commission for Europe, called " Relationship between Coal and Black Oils in the West European Fuel Market " (3*s*. 9*d*.). The report deals with the energy requirements in Western Europe during the next ten years. It assumes that atomic energy is not likely to make any major contribution to fuel supplies within that time and that demand will therefore have to be met by coal, oil, natural gas and hydro-electricity.

Controversy may arise over the Commission's assumption about the prospective demand for energy and the proposal they put forward that Europe's oil industry should be developed to cater for the marginal supplies of energy which may be required. This would mean expanding the oil industry so that it can cope with maximum demand at any time, also taking the slack from time to time due to short-period fluctuations in the demand for fuel and power. In the past these fluctuations have had to be absorbed by the coal industry but the report now suggests that since the oil industry's manpower is much smaller than the coal industry's, full employment should be maintained in coal while fluctuations are allowed to occur in oil. Owing to the high output per head in the oil industry it is probable that short-term fluctuations in demand could be absorbed without causing serious unemployment in the oil industry whereas a corresponding fluctuation in demand for coal might lead to serious unemployment in the mines.

Forecasting the demand for energy is perhaps a somewhat hazardous business but the Commission's efforts to do so are probably as reliable as anyone else's. They assume a 2·5 per cent. average annual increase in gross national production and a gradual reduction in the energy consumed per unit of national output of 1·2 per cent. per year. On this basis the apparent consumption in the Western European energy market might reach 750 million tons in coal equivalent by 1963, an increase of 13·5 per cent. over 1953. They assume that the requirements of hard coal will vary from 470 million tons in coal equivalent per year to 513 million tons by 1963, depending on the output of finished oils from the petroleum industry. It is almost certain, however, that the variation will be between 490 million tons and 513 million tons, figures which may be compared with 480 million tons in 1953. It is thus apparent that a gradual expansion in the coal industry is likely. The variations in the gap between the total demands for energy at 750 million tons a year and the estimated requirements of hard coal are accounted for by the different assumptions which have been made about the total output of the petroleum industry. It has been assumed that hydro-electricity, natural gas and imported coal will make important contributions towards closing the gap but their contribution will gradually increase and will not fluctuate.

It is the fluctuating role for the petroleum industry which will probably be most controversial. The report recommends the installation of additional catalytic cracking facilities, so increasing its flexibility, including within that its ability to meet growing demand. It is apparent, however, that this flexibility can be exploited on the lines outlined by the E.C.E. only if the demand for white oils as well as black oils can be increased. There are limits beyond which it is not possible to increase the capacity for residual fuel oils without increasing the capacity for white oils as well, a complication of which the authors of the report are clearly aware. The expansion of black-oil capacity therefore brings with it the need to find an outlet for a larger consumption of the lighter fuel oils, of which petrol for cars is a main constituent. Consideration of this problem leads on to complications of fiscal policy in the countries concerned, so that any concerted plan for the development of the petroleum industry on the lines suggested must begin in the Chancellories of Western Europe rather than in the boardrooms of the oil companies.

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B.O.A.C. PROFIT IN SPITE OF DISASTER

The series of Comet catastrophies—near Calcutta in May, 1953, south of Elba, in January, 1954 and south of Naples, in April, 1954—must have raised doubts in many minds as to whether the introduction of jet-propelled aircraft for commercial passenger carriage was premature. British Overseas Airways Corporation do not share these doubts. In their annual report for the year ended March 31, 1954, the chairman Sir Miles Thomas has said " I want to make it quite clear that we have as much faith in the future of jet-propelled aircraft as when we ordered Comets seven years ago off the drawing board. With the whole of the country's aircraft engineering resources harnessed and vigorously working to discover what is at fault, we are satisfied that the answer will be found, formidable as is the task presented."

After nearly five years without an accident fatal to passengers, in the year 1953–1954, B.O.A.C's safety record was tragically broken. In addition to the first two Comet break-ups (the third occurring after the end of the financial year), on March 13, a Constellation aircraft overturned and caught fire on landing at Singapore. In spite of these disasters, and of the loss of revenue from the grounding of the Comet fleet between January and March after the Elba accident, the Corporation earned a profit of £2 million.

During the year there were two major changes in the aircraft fleets—the retirement of the Hermes in the autumn of 1953, made possible by increasing the utilisation of more economic aircraft; and the withdrawal of the Comets, resulting in the loss of 21 per cent. of the planned capacity for 1954–55.

To overcome the shortage of aircraft, South American services, operated by Argonauts, were temporarily withdrawn. The Argonaut capacity thus gained has been applied to the African and Eastern routes over which the Comets had been operated.

Meanwhile the Corporation, with Government approval, is acquiring as a temporary stop-gap additional Stratocruiser and Constellation 749 aircraft pending the reinstatement of the de Havilland Comets, of which twelve Series 2 and five Series 3 are on order, and delivery of the Bristol Britannia fleet, 25 of which are on order.

The Corporation have renewed their interest in the Princess flying boat and believe that "in approximately five years' time the progress made with turbo-jet and turbo-propeller engines will offer interesting possibilities of increased range with improved economy of operation." The Corporation are also assessing the probable capabilites of proposed civil versions of the three types of V-class jet bomber aircraft, and are "taking a forward view of the potentialities of the many varied and important turbo-jet and turbo-propeller developments."

With the advancement of the building at London Airport, which will provide office accommodation for headquarters staff as well as extensive workshops and four hangar bays for the engineering and operations departments, the Constellation fleet maintenance organisation has been transferred from Filton to London Airport, and it is expected that the Stratocruiser fleet also will be transferred before the end of 1954.

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SELLING AND COSTING

The fifth annual residential summer school of the Institute of Cost and Works Accountant was held last week. The four papers round which the course of study was compiled were all connected with the problem of costs in relation to sales. The functions of the cost accountant in the selling and distribution side of a business are of immediate concern to the works' manager for costing has an important part to play in formulating and checking sales policy and production policy.

The first paper at the conference dealt with "Problems of Compilation of Selling and Distribution Costs." The main purpose of this paper was to show that proper account classification and the correct use of budgetary control and standard costs are as applicable to selling and distribution accountancy as they are to manufacturing costs. The use of standard costs, however, has to be used with discrimination in this field. The second paper, on "The Interpretation and Use of Selling and Distribution Costs," showed that although there are similarities of principle between costing for distribution and costing for manufacture, the costing problem is much more complex in the former case because selling and distribution expenditure bears no special relationship to the value of the product and may be only a small proportion of the total. Nevertheless, the aim should be to increase the degree of control exercised by management by improving costing techniques on the sales side. The third paper dealt with "The uses of Costs in the Fixing of Prices, with Special Reference to Marginal Costing," the speaker pointing out that although marginal costing can be dangerous if used by inexperienced people, it could also be used for giving clear danger signals. It is certainly true that until some adequate form of marginal costing is used, a company can have little appreciation of the way the burden of overhead expenses falls on individual products and individual departments. The last paper was entitled "What the Sales Side wants from the Accountant." The speaker made the interesting point that in his opinion it was better to have a good figure man rather than a good sales man as sales manager, if one had to choose between extremes. He pointed out also that until a sales manager knew when to use figures and when to ignore them and rely on his own judgment, he would not be able to make the maximum use of the information from the costing department.

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VAUXHALL'S EXPANSION

A further large investment programme by Vauxhall Motors, Limited, has been expected for some time. Not much was known, however, about its nature and amount. It was announced last week that the company will spend £36 millions over the next five years. This is a very large sum by any standard. On the one hand it can be compared with the existing fixed assets of the company, valued at present at about £7 millions; on the other, it is about the size, measured in money, of the big steel expansion programme recently announced by Dorman Long. Some of the money is to be spent on replacements for existing equipment, but most of it is for new machinery.

The market forecasting behind this investment indicates an anticipated large increase in the overseas sale of Vauxhall vehicles, notably commercial vehicles. At present Vauxhalls export almost 130,000 cars and Bedford trucks, and the new programme will enable the company to double its exports through the General Motors' world-wide export organisation. In the home market the company expects a million more cars to be in operation by 1960, that is an increase in motor vehicles from the present figure of 4,100,000 to about 5 millions.

This must be one of the most ambitious scrap-and-build programmes put in hand by British industry since the war. The company insist that they propose holding and, if possible, increasing their share of the market by using capital development as a means of achieving a reduction in costs. This is an attitude of mind which owes something no doubt to the parent company in the United States, for General Motors, like all the large American automobile manufacturers, do not hesitate to re-tool on a huge scale in order to get their costs down. Just as in the United States, General Motors and Ford are currently increasing their hold on the American home market, so, in this country, their subsidiaries the Ford Motor Company at Dagenham and Vauxhall Motors at Luton have, in the last year or two, increased their challenge in the British home market. Last week's announcement from Vauxhall Motors is a clear indication that so far as they are concerned the challenge is to be intensified.

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BOMBER AIRCRAFT DESIGN

In the eleventh Gustave Canet Memorial lecture, on "Some of the Problems of Bomber Design," presented by Mr. David Keith-Lucas, at the opening of the new headquarters of the Junior Institution of Engineers in London, on September 24, (see page 420), the lecturer said that the penetrating power of a bomber aircraft depended on its ability to take punishment, to fight off enemy attacks, and to avoid interception.

Owing to the weight and drag of defensive armament, for which automatic radar sighting gear would probably be required, it would probably be more efficient to concentrate design on the ability to avoid interception. At altitudes of 60,000–70,000 ft., although the rocket fighter or guided weapon had an appreciable margin of performance over the jet bomber, it could not carry enough fuel to sustain a long chase. At such altitudes, however, the bomber had a very small power of manoeuvre.

Other possibilities for avoiding guided weapons were to fly faster than the enemy could launch his missiles or so low that they could not intercept because of ground interference. The latter possibility would require special aids for navigation, and would demand a wing loading of 200–300 lb. per square foot, in order to get adequate range. Stowage would be difficult and take-off problems formidable. The alternative of flying fast at relatively high altitude required high supersonic speeds to give adequate range; and at Mach numbers above 2 the aerodynamic heating problem raised severe cooling problems.

This led to the consideration of the expendable pilotless bomber, which, owing to the deletion of half the fuel carried and much of the equipment, could be much smaller and simpler than the piloted aircraft and, therefore, as economic. If it had the penetrating power, and if the navigation problem could be solved, Mr. Keith-Lucas said, probably no more piloted bombers would be built. The German V2 rocket flew so high and so fast that not one was intercepted before it reached its target. Its range varied over wide limits (160 miles to 220 miles) and 15 to 20 per cent. of the rockets exploded in the air before reaching the target.

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RETURN OF THE STEAM ENGINE

Here is a new steam engine! A steam engine embodying materials and principles of design normally associated with the engines that displaced it. Much of the research and development work expended on the internal-combustion engine have been used to advantage in designing it. If its sponsors are not mistaken it will be the means of cheap mechanical power for primitive communities—the first stage in the mechanisation of their agriculture, a step towards industrialisation, and a help in raising their standard of living.

The drawings reproduced in this issue of ENGINEERING reveal the novelty of this design. Several engines have been exhaustively tested, under the supervision of Brigadier M. H. Cox, who has had wide experience in India, Pakistan and other Eastern countries. It is a small machine of 2½ brake horse-power (one of twice that power may also be built) and its boiler—a light-alloy casting with integral fins—can be mounted on a furnace to burn agricultural wastes such as sugar-cane trash, cotton stalks, etc., as well as coal, wood or peat.

Many uses for the engine can be envisaged—some are described in the main article. For irrigation it is estimated that one acre of land would grow enough fuel to provide power for irrigating 50 acres, assuming the water table to be at a depth of 30 ft. There would be none of the difficulties of imported fuels or hydro-electric power (low water levels in Mysore reservoirs have resulted in 85 per cent. power cuts), and the need for frequent refuelling should not be serious in countries where labour is cheap.

Two years ago the report of a special committee on the utilisation of solar energy was published (ENGINEERING, vol. 174 (1952), pages 601, 607, 645 and 679). The report concluded with a reference to the development of this engine by Ricardo and Company (1927), Limited, for the National Research Development Corporation, but it also reviewed the scope for developing other ways of using solar energy.

INFORMATION AND TECHNICAL LIBRARIES

Aslib's Twenty-Ninth Conference

The communication of ideas was one of the principal themes of the twenty-ninth annual conference of Aslib (Association of Special Libraries and Information Bureaux), held in London from September 24 to 27. The opening address was given by the chairman, Dr. Barbara Wootton, Nuffield Research Fellow, Bedford College, on " Further Problems of Communication," to which she added a sub-title, " The language of the social sciences." She discussed the difficulties arising in communication from the use of the same word to express several different ideas—of which the word " communication " itself was an example—and from the emotional association attached to words in general use.

On Sunday morning, the application to library problems of the theory developed by communications engineers for coding, transmitting and decoding information was discussed by Mr. R. A. Fairthorne, of the Royal Aircraft Establishment, in a paper entitled " The Theory of Communication." This theory, still under development, should be able to provide a basis for assessing the efficiency of the library service—the chances of finding the information sought and the economy of the classification and retrieval systems adopted.

The other sessions departed from the communication theme. On Saturday morning, the discussion centred on " The Scientist as Information Officer," Mr. E. B. Uvarov putting the view of the scientist and Dr. R. M. Lodge stating the needs of the employer—in this case, the research manager. The most valuable contribution to this discussion was that of Dr. D. J. Urquhart, Department of Scientific and Industrial Research, who reminded the delegates that the vast majority of British industrial firms had no library service and few science graduates, and that the major problem confronting industry was to find ways of circulating new ideas and information to these small but highly important firms.

The Saturday afternoon sessions were concerned with " Equipment of Current Interest to Information Workers and Librarians," presented by Mr. L. J. Anthony, assistant director of Aslib, and a summary of " Aslib's Development," given by the director, Mr. Leslie Wilson. In the final session, on Sunday afternoon, Mr. Robert C. Sale, United Aircraft Corporation, U.S.A., Mr. G. A. Lloyd, British Standards Institution, and Mr. B. C. Brookes, representing the Presentation of Technical Information Discussion Group, discussed " The Function of the Library in Preparing and Producing Technical Papers."

* * *

MAINTENANCE OF PUBLIC HEALTH

Co-operation between Institutions

Fifteen professional and technical bodies concerned with the maintenance of public health have agreed to co-operate with the Royal Sanitary Institute in setting up machinery whereby liaison between them can be placed on a permanent basis.

It is felt that such an arrangement would assist the interchange of ideas between personnel engaged on the promotion of public health.

Among the organisations who have given their approval to the scheme are the Institution of Civil Engineers, the Institution of Municipal Engineers, the Institution of Sanitary Engineers, the British Occupational Hygiene Society, the National Smoke Abatement Society and the Royal Sanitary Association of Scotland.

THE JUNIOR INSTITUTION OF ENGINEERS

NEW HEADQUARTERS OPENED BY LORD FALMOUTH

The new headquarters building of the Junior Institution of Engineers at Pepys House, 14 Rochester-row, Westminster, S.W.1, was formally inaugurated by the Rt. Hon. the Viscount Falmouth, a past President of the Institution, on Thursday evening, September 23, in the presence of a large gathering of the members and their friends, including the President-elect, Professor S. J. Davies, D.Sc., and Mrs. Davies. The chair was taken by Mr. S. G. Clark, chairman of the Institution, who welcomed Lord and Lady Falmouth and the numerous guests, and expressed the regret of the President, Sir John Hacking, M.I.E.E., that he was unable to be present: Sir John had sailed for Australia a few days before the meeting. He then called on Mr. J. Foster Petree, a past chairman of the Institution, to give a short outline of its origin and development.

Describing the meeting as " a unique occasion in the history of a unique Institution," Mr. Petree described how the J.I.E. had orginated in 1884 as a society of apprentices in the Lambeth works of the famous firm of Maudslay, Sons and Field. The first meeting was held on June 30, 1884. Initially, the title was the Vulcanic Society. The first chairman, who was also the secretary, was Philip H. May, who was succeeded, in December of that year, by Sidney H. Welis, later to become Principal of Battersea Polytechnic. An early rule decreed that " no gentleman above 26 years of age is eligible for membership "—but that rule did not last long; apparently, it was abandoned at about the time that the original members became 26. Several of them achieved over half a century of membership.

CHANGES OF NAME

The Society underwent many changes of name—to the Lambeth Junior Scientific Society, the Junior Engineering and Scientific Society, the Junior Engineering Society, the Institution of Junior Engineers, and finally, in 1902, the Junior Institution of Engineers; but always the principle was maintained that it existed, first and foremost, for the junior members of the engineering profession. It was a tribute to the success of that policy that so many members to whom the description once applied had retained their membership long after they had acquired an indisputably senior status. On the present Council of the Institution there were full corporate members of the Institutions of Civil, Mechanical and Electrical Engineers, of Structural and Gas and Water Engineers, of Naval Architects, of the Institutes of Metals and of Fuel, of the Royal Aeronautical Society, and of other professional bodies; and every one of them had been elected to the Council from the ranks of the Juniors themselves.

For more than 50 years the Institution had offices at 39 Victoria-street, where, over a long period, the meetings were also held; but the rising cost of rented accommodation led the Council to seek their own freehold premises. These they found in Pepys House, formerly the Parish House of the combined parishes of St. Stephen with St. John, Westminster. The cost —more than £20,000, with the necessary redecoration and furnishing—was a heavy item for an Institution of only some 1,500 members; but the members had supported the venture vigorously and already considerably more than half of the money had been found, much of it in free gifts and in loans without interest. The Institution had done a great deal of pioneer work—it was believed to be the first to establish local sections (in Birmingham, in 1907), to organise visits to works as a regular feature, and to hold informal meetings—and the Council were confident that the improved facilities now available would be an asset of increasing value.

The chairman then invited Lord Falmouth to declare the building open.

Lord Falmouth said that, while regretting the unavoidable absence of Sir John Hacking, he appreciated greatly the invitation to take his place, for he had always taken a keen interest in the activities of the Institution. He congratulated the chairman, Council and members on the success they had achieved in acquiring their own premises. It had taken them a long time—70 years—to get a home of their own, but at last it had been accomplished, thanks to the methodical work of the chairman, Council and secretary, and the support they had received from the members. It was with great pleasure, that, as a " Junior," he formally declared the building open for the use of the Junior Institution of Engineers.

THE NEW HEADQUARTERS

Pepys House, a brick building in what is officially described as the " Victorian Gothic " style, has a frontage of 65 ft. on Rochester-row and a depth of 34 ft. The main floor is entered from the street by wide steps leading to a large entrance hall, on the left of which is the main lecture room, 42 ft. long and 28 ft. wide, with a height of 14 ft. 6 in. It will seat about 150 and has a raised platform at one end. The equipment includes a sound cinematograph projector, a lantern and an epidiascope. On the right of the entrance hall are the secretary's and general offices. Beneath the main hall is another room of equal area, and the kitchen, lavatories, etc. On the first floor is the library, a lofty room measuring 22 ft. 3 in. by 19 ft. 6 in., with a large oriel window. Further office accommodation is on the same floor and on the floor above. The original pitched roof over the main hall, which was damaged during the war, was replaced by a flat roof, so that there is the possibility, if necessary, of extending the premises at that level. The building, which has been extensively redecorated, is fitted with central heating throughout. The acoustic properties of the lecture hall are notably good.

THE GUSTAVE CANET LECTURE

On the evening following the formal opening, the first ordinary meeting of the 1954-55 session was held in the new hall, when Mr. D. Keith-Lucas, B.A., M.I.Mech.E., F.R.Ae.S., delivered the eleventh Gustave Canet Memorial Lecture, taking as his subject, " Some of the Problems of Bomber Design." Mr. Keith-Lucas, who is a director of Short Brothers and Harland, Limited, first outlined the course of bomber development since the introduction of this type of aircraft in the 1914-18 war, and then indicated how the factors which successively limited bomber performance had been overcome. In necessarily general terms, he then proceeded to suggest possible future lines of development, while admitting that the problems of taking-off and landing the aircraft of the future still presented many difficulties, not all of which could yet be solved. Further reference to this lecture is made in a Weekly Survey note in this issue.

At the conclusion of the lecture, Air Commodore F. R. Banks, C.B., O.B.E., the immediate past-President of the Institution, who occupied the chair, presented to Mr. Keith-Lucas the commemorative Gustave Canet Medal and the certificate of his election as a Vice-President of the Institution. Gustave Canet, the eminent French artillerist, was President of the Junior Institution in 1908-9. He died towards the end of his year of office, and his family founded the lectureship in his memory.

PERSONAL

MR. C. M. SPIELMAN, O.B.E., M.C., M.I.C.E., M.I.Struct.E., managing director of Whessoe Ltd., Darlington, since 1935, has relinquished that position from September 30, and has been succeeded by MR. A. G. GRANT, M.Sc., M.I.Chem.E., M.Inst.GasE., director and general manager of the company. Mr. Spielman is retaining his seat on the board.

MR. C. F. JACKSON, assistant general manager at the Willesden Works of Lancashire Dynamo and Crypto, Ltd., has been appointed general manager at these works as from September 1.

MR. E. C. LENNOX will be installed as President and will read his presidential address at the opening sessional meeting of the Illuminating Engineering Society, 32 Victoria-street, London, S.W.1, to be held at the Royal Institution on October 12.

MR. F. W. LAMPARD has been appointed northern manager of Silentbloc Ltd., and the Andre Rubber Co. Ltd. He will work from the Huddersfield office of these two companies, at 11 Cloth Hall-street.

MR. W. L. COLE, F.C.I.S., and MR. D. BAYLISS, who were appointed directors of Perry and Co. (Holdings), Ltd., in 1953, and MR. W. A. MCLEOD, who was appointed a director of the firm last month, have now been made assistant managing directors of the company.

MR. ERNEST DALE retired from the position of director and works manager of the NORTH EASTERN MARINE ENGINEERING CO., (1938) LTD., Wallsend-on-Tyne, on September 30.

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BUSINESS CHANGES

As from October 6, the WATER POLLUTION RESEARCH LABORATORY, will be moving from its temporary premises in Watford, Birmingham, and elsewhere, to a new permanent building in Elder Way, London-road, Stevenage, Hertfordshire. (Telephone: Stevenage 820.) Most of the staff will be moving in during October but it is likely to be some time before all the equipment is installed and work is proceeding smoothly.

CLAUDE LYONS LTD., 76 Oldhall-street, Liverpool 3, who are manufacturers of Variac transformers, automatic voltage stabilisers and other laboratory instruments, have opened a new Southern Area factory, known as Valley Works, at 4–10 Ware-road, Hoddesdon, Hertfordshire. (Telephone: Hoddesdon 3007/8/9.)

RICHARD COSTAIN LTD., inform us that from Monday, October 4, their address will be 111 Westminster Bridge-road, London, S.E.1. (Telephone: WATerloo 4977.)

As a result of an extraordinary general meeting of shareholders, the name of the steelmaking firm in Holland, KONINKLIJKE NEDERLANDSCHE STAALFABRIEKEN v/h J. M. DE MUINCK KEIZER N.V., has been altered to KONINKLIJKE DEMKA STAALFABRIEKEN, N.V., Utrecht, Holland.

THE MOND NICKEL CO., LTD., Thames House, Millbank, London, S.W.1, on behalf of their parent company, THE INTERNATIONAL NICKEL CO. OF CANADA, LTD., announce that, following negotiations between ASSOCIATED ELECTRICAL INDUSTRIES LTD., the Mond Company and BIRLEC LTD., the sale by the Mond Company of their wholly-owned subsidiary company, Birlec Ltd., to Associated Electrical Industries, has been agreed. Birlec Ltd. will operate as an individual company within the A.E.I. Group. MR. G. P. TINKER will continue as managing director and MR. T. G. TANNER and MR. J. H. CROSSLEY as executive directors.

THE INSTITUTION OF ENGINEERING DESIGNERS has now established its own headquarters at 38 Portland-place, London, W.1. (Telephone: LANgham 8847.)

As at the close of business on October 2, three new wholly-owned subsidiary companies will take over the trading activities of DORMAN, LONG & CO., LTD., Zetland-road, Middlesbrough. The first, DORMAN, LONG (BRIDGE AND ENGINEERING) LTD., will take over the trading activities carried on at the Bridge and Constructional Works, Middlesbrough, and the London Constructional Works, and at the Bridge and Contracting Department, Luton. The second company, DORMAN LONG (CHEMICALS) LTD. will take over the trading activities of coal by-products distillation, etc., carried on at Port Clarence. Finally, DORMAN LONG (STEEL) LTD. will take over all the direct trading activities of Dorman Long & Co. Ltd., other than the above.

Obituary

MR. A. B. COOPER

Electrical Engineering in Canada

We regret to record the death of Mr. A. B. Cooper, which occurred at Toronto on Wednesday, September 15, at the age of 70. He had for many years been head of the Ferranti organisation in Canada and was well known to electrical engineers in that Dominion.

Ashton Burton Cooper was born at Bloomfield, Ontario, on December 31, 1883, and was educated at the Somerville Latin School, Somerville, Massachusetts. He received his technical training at Tufts College, Boston, and subsequently served his apprenticeship with the General Electric Company of America at Schenectady, and with the Pearson Engineering Corporation of New York.

At the beginning of 1909 he rejoined the General Electric Company as a commercial engineer and four years later became manager of the Transformer Sales Department of the Canadian General Electric Company. He was appointed general manager of Ferranti Electric, Limited, in Toronto in 1923 and became president in 1942, a position he was holding at the time of his death. During his period of service, in addition to the general duties of management, he directed engineering policy and supervised the sales department. He was elected to the Board of the parent company, Ferranti Limited, in 1947.

Mr. Cooper became an Associate Member of the Institution of Electrical Engineers in 1929 and was transferred to the class of member in 1945. He served for a time as local honorary secretary of the Institution in Canada. He had also been a vice-president of the American Institute of Electrical Engineers and President of the Toronto Industrial Commission and of the Association of Professional Engineers of Ontario. He was a former President of the Canadian Electrical Manufacturers Association, and had been chairman of the Toronto Branch of the Canadian Manufacturers Association.

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We regret also to record the deaths of:

MR. FREDERICK GRANT, M.C., Q.C., on September 19 at the age of 64. Mr. Grant was a former assistant secretary of Bolckow, Vaughan and Co., Ltd., steelmakers, Middlesbrough, and in September, 1953, was elected independent chairman of the executive committee of the British Iron and Steel Federation, Steel House, Tothill-street, London, S.W.1, in succession to the late Sir Andrew Duncan.

MR. STANLEY WALTER HUGHES, suddenly in London on September 22 at the age of 68. He was chairman and managing director of H. M. Hobson, Ltd., makers of aircraft-engine components, Fordhouses, Wolverhampton.

MR. LESLIE PRESTON PARKER, O.B.E., B.Sc.(Eng.) (Lond.), Wh. Ex., M.I.C.E., M.I.Mech.E., M.I.Loco.E., at Chigwell Row, Essex, on September 23, in his 66th year. Mr. Parker retired from the position of motive-power superintendent for the Eastern Region of British Railways at Liverpool-street Station, London, E.C.2, on October 21, 1953.

MR. HERBERT EDWARD TAYLOR, at West Bridgford, Nottingham, on September 23 in his 72nd year. Mr. Taylor was joint managing director of Taylor Bros. (Sandiacre), Ltd., Midland Foundry, Sandiacre, near Nottingham.

DR. CHARLES EDWARD LARARD, M.I.C.E., M.I.Mech.E., on September 23, at the age of 86. He was a former head of the Civil and Mechanical Engineering Department of the Northampton Polytechnic, St. John-street, London, E.C.1. The Senate of the University of London conferred upon him the degree of D.Sc. (Eng.) on July 20, 1932.

MR. JOHN WEBB, C.M.G., C.B.E., M.C., M.I.E.E., suddenly on September 12, at Gwelo, Southern Rhodesia, at the age of 69. He was formerly Inspector-General of the Egyptian State Telegraphs and Telephones, having been appointed to that office in 1931.

COLONEL AUTHUR HAROLD BIRCHALL, M.C., on September 24, at Newcastle-upon-Tyne, at the age of 67. He was a partner in the firm of J. O. Morgan and Birchall, consulting marine engineers, Newcastle, and was a founder member of the Society of Consulting Marine Engineers and Ship Surveyors.

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Letters to the Editor

THE VALUE OF CHANGE

Responsibility for Training

SIR, It was with great interest that I read the leader on "The Value of Change" in ENGINEERING of September 24. I have, over several years, endeavoured from observations and study to construct graphs of the type you show for all strata of industrial activity.

As you so rightly say, the difficulty of measuring the value of the engineer's service to his employer is immense. I have used several yardsticks. Not a very good one at all is remuneration or salary. A better standard is an assessment somewhat similar to merit ratings which are used to-day in industry. This, of course, is arbitrary, but if carried out on a reasonably broad basis, can give quite good comparative results.

Even though the veneer of management over the whole of industry is so very thin, little attention is yet paid to the training of future generations of managers and key personnel. Because of this, the opportunity does not arise as often as it should for a man to be able to change the type of his employment within an organisation or industry or even between industries. For example, there is little interchange between the commercial and design departments, or between research and production; in research, opportunity is seldom given to acquire administrative experience at a suitable age. Attention is paid to the education and training of specialists but little or none to the raising of "specialists on specialists," e.g., industrial engineers. The situation is fortified by the present type of industrial organisation and by the present policies of the professional institutions and universities. This is due, as I see it, entirely to the lack of management training and little appreciation on the part of management of the necessity to ensure their succession.

Thus, your article pin-pointed a vital lacuna which is present in management training and responsibility.

Yours very truly,
L. LANDON GOODMAN.

2 Savoy Hill,
London, W.C.2.
September 28, 1954.

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FILM OF THE SUPERGRID

The J. L. Eve Construction Company, Limited, 17 Hillside, London, S.W.19, recently gave a showing in London of their film concerning the construction of the Tilbury-Elstree section of the 275-kV Supergrid. This film was previously shown at the C.I.G.R.E. conference in Paris.

The film shows the various methods employed for different parts of the construction, including the use of a floating derrick where the ground area was limited. The method has been described in a paper read before the Institution of Civil Engineers. Methods of paying out the conductors, of fixing them in place, and of fixing the spacers between them, were also shown.

CONTRACTS

Power-Station Extension. With the approval of the Northern Ireland Ministry of Commerce, the chairman of the Northern Ireland Joint Electricity Committee has awarded three contracts in connection with the Belfast municipal electric power station west second extension. The first is for a 60 MW turbo-alternator, valued at £738,000 and placed with C. A. Parsons & Co., Ltd., Newcastle-upon-Tyne; the second for two 220,000 lb. per hour boilers, valued at £704,000 and placed with MITCHELL ENGINEERING, LTD., London; and the third, worth £36,000 and for the main excavations and piling, placed with STEWART AND PARTNERS, LTD., Belfast.

Television Transmitters. The Independent Television Authority has placed an order for six television transmitters (three vision and three sound) with MARCONI'S WIRELESS TELEGRAPH CO. LTD., Chelmsford, Essex. The vision transmitters will be 10 kW and the sound transmitters 2½ kW.

Gasholder. The North Shore Gas Co., North Sydney, Australia, have entrusted THE POWER-GAS CORPORATION (AUSTRALASIA) PTY. LTD. (a subsidiary company of THE POWER-GAS CORPORATION LIMITED, Stockton-on-Tees) with an order for the supply, delivery and erection, at Willoughby, New South Wales, of a one-million cub.-ft. capacity three-lift spiral guided gasholder, complete with steel tank. The tank and all lifts will be of welded construction and all materials will be of Australian manufacture.

Power-Station, Transforming-Station and Transmission-Line Equipment.—Contracts have been placed by the British Electricity Authority during the past few weeks for power-station, transforming-station and transmission-line equipment, amounting in the aggregate to £19,575,572. The principal contracts include, for Littlebrook "C" power station, Dartford: high-pressure pipework and valves, with C. A. PARSONS & CO., LTD.; for Portishead "B" power station, near Bristol: two brick chimneys, with CHIMNEYS LTD.; for Goldington power station, Bedford: one 300,000 lb. per hour boiler, with CLARKE, CHAPMAN & CO., LTD.; for South Denes power station, Yarmouth: coal-unloading plant, with MITCHELL ENGINEERING LTD., and coal-elevating and conveying plant, with INTERNATIONAL COMBUSTION LTD.; for Castle Donington power station, near Derby: subsidiary buildings, with TAYLOR WOODROW CONSTRUCTION LTD., and one 106-MVA 275-kV transformer, with METROPOLITAN-VICKERS ELECTRICAL CO. LTD.; for Drakelow "A" power station, Burton-on-Trent; two 515,000 lb. per hour boilers, with INTERNATIONAL COMBUSTION LTD.; for Drakelow "B" power station: one 120,000-kW turbo-generator, condensing, feed-heating and evaporating plants, with C. A. PARSONS & CO. LTD.; for Willington "A" power station, near Derby: structural steelwork with EDWARD WOOD & CO., LTD., and coal-handling plant, with THE NEW CONVEYOR CO., LTD.; for Hams Hall "C" power station, near Birmingham: three 60,000-kW turbo-generators, with THE GENERAL ELECTRIC CO., LTD., and condensing and feed-heating plants for three turbo-generator sets, with WORTHINGTON-SIMPSON LTD.; for Bold "B" power station, St. Helens: one 60,000-kW turbo-generator, with THE GENERAL ELECTRIC CO. LTD., and condensing and feed-heating plants for a 60,000-kW turbo-generator, with HICK, HARGREAVES & CO., LTD.; for Connah's Quay power station, near Flint: two 300,000 lb. per hour boilers with INTERNATIONAL COMBUSTION LTD., two 30,000-kW turbo-generators, condensing and feed-heating plants, with C. A. PARSONS & CO., LTD., and 3,300-volt and 415-volt auxiliary switchgear, with A. REYROLLE & CO., LTD.; for the Dolgarrog hydro-electric scheme, Caernarvonshire: extension of the catchment, with JOHN LAING & SON, LTD.; for Elland and Ferrybridge "B" power stations, Yorkshire: site clearance, road and railway embankments, flood-protection banks, access roads and other works, with HOLLAND & HANNON AND CUBITTS, LTD.; also for Ferrybridge "B" power station, a cooling tower, with DAVENPORT ENGINEERING CO., LTD.; for Wakefield power station, Yorkshire, three 550,000 lb. per hour boilers, with FOSTER WHEELER, LTD.; for Chadderton power station, Oldham: three 360,000 lb. per hour boilers, with SIMON-CARVES, LTD.; for Huncoat power station, Accrington: condensing and feed-heating plant for one 30,000-kW turbo-generator, with HICK, HARGREAVES & CO., LTD.; for Portobello power station, Edinburgh: one 540,000 lb. per hour boiler, with INTERNATIONAL COMBUSTION LTD.; for Dalmarnock power station, Glasgow: high-pressure pipework and valves, with STEWARTS AND LLOYDS LTD.; for Brighton (Fishergate) substation: 33-kV 730-MVA switchgear, with A. REYROLLE & CO., LTD.; for Norwich substation: 33-kV 750-MVA switchgear, with A. REYROLLE & CO., LTD.; for Stella West substation, Newcastle-upon-Tyne: 275-kV 7,500-MVA switchgear, with A. REYROLLE & CO., LTD.; 132,000-volt lines for Yarmouth to Norwich and Ipswich to Yarmouth, with W. T. HENLEY'S TELEGRAPH WORKS CO., LTD.; and a 275-kV overhead line from Monk Fryston to Skelton Grange, Yorkshire, with BALFOUR, BEATTY & CO., LTD.

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THE IRON AND STEEL INSTITUTE

Autumn Meetings

The autumn general meeting of the Iron and Steel Institute will be held on Wednesday and Thursday, November 17 and 18, at the offices of the Institute, 4 Grosvenor-gardens, London, S.W.1.

The meeting opens at 9.45 a.m. on the first day with formal business and the election of members. Two papers, the first on the future of steel melting and the second on an aspect of the continuous casting of steel will then be presented and discussed. The afternoon session, from 2.30 to 4.30, will be devoted to a joint discussion on five papers concerned with the effects of cold-work, ageing, and strains on steel.

On the second day, from 10 until 11.30 a.m., two papers on reheating furnaces and the reheating of steel ingots will be presented and jointly discussed, and, from 12 noon until 1.15 p.m., two papers on flames and preheating in open-hearth furnaces will be dealt with. In the afternoon, a special report (No. 50) on fatigue tests on rolled alloy steels will be discussed.

FORGINGS

The Iron and Steel Institute also announces that a joint meeting with the National Forgemasters' Association and the Chambre Syndicale de la Grosse Forge Française will be held at 4 Grosvenor-gardens on Tuesday and Wednesday, October 12 and 13.

Papers by members of the Chambre Syndicale and of the Forgemaster's Association will be presented. The subjects to be dealt with include the ultrasonic inspection of heavy upset forgings, the making of a large reaction vessel in alloy steel, a new forge shop at Firminy, the continuous grain-flow process, thermal stability testing of rotor forgings, trepan boring using tungsten-carbide tipped tools, a 35,000-ton die-forging press for light alloys, and heating and soaking times in large furnaces.

JET-LIFT RESEARCH VEHICLE

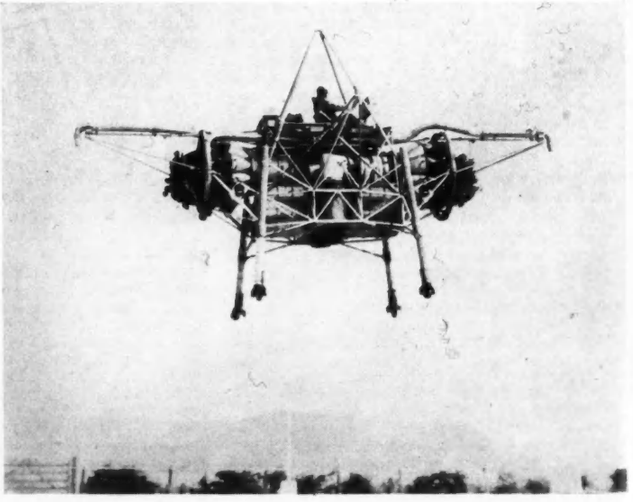
Some further details and a photograph of the research vehicle for vertical lift with jets (the "Flying Bedstead"), the existence of which was disclosed recently by the Minister of Supply, have now been released by the Ministry. As may be seen in the accompanying illustration, in order to eliminate gyroscopic effects the two Rolls-Royce Nene engines are horizontally opposed at either end of the framework, which is of braced tubular construction. The jets from these engines are ducted through 90 deg. so that both engines discharge vertically downwards under the centre of gravity of the machine.

The vehicle was constructed by Rolls-Royce Limited, Derby, on a Ministry of Supply research contract, to examine the basic control problems of a craft capable of taking off and landing in a near-vertical flight path. No attempt was made to develop special engines. The simplest and lightest possible framework was built to accommodate existing engines. Rolls-Royce Nene centrifugal jet engines, the officially-rated static thrust of which is 5,000 lb. at sea level, were available and afforded sufficient reserve thrust to carry a pilot and adequate fuel for a reasonable flight duration. The weight of the vehicle is 3½ tons.

The pilot, seated on a platform above the engines, controls the machine in pitch, roll and yaw, through a conventional control column and rudder bar, which regulate compressed-air jets discharged through nozzles at the end of cross arms, the pitch-control nozzles being clearly visible in the illustration. The compressed air for control is bled from both engines.

In the initial tests, in order to safeguard the machine and the pilot, the vehicle was tethered to allow it only a few feet of movement. The limits were increased as experience and confidence were gained in its handling, but on August 3 all the check wires were removed and the vehicle, piloted by Captain Shepherd, took off in free flight from Hucknall Aerodrome and remained airborne for about 10 minutes at heights of from 5 to 10 ft. Subsequently it has been flown free at heights up to 25 ft.

The Ministry of Supply release concludes with the statement—which is perhaps self-evident—that "a great deal of investigation and development remains to be done. For example, the problem of heat, noise, safety and the design of the most efficient engines and an airframe to employ this principle have all to be tackled and solved."



The Rolls-Royce jet-lift research vehicle, general particulars of which have been released.

THE INSTITUTION OF NAVAL ARCHITECTS AUTUMN MEETING

COMMEMORATING FROUDE'S FIRST SHIP-MODEL TOWING TANK

For the first time in its history, the Institution of Naval Architects this year held its Autumn Meeting in Torquay, from Tuesday, September 21, to Friday, September 24. The reason was the special one of commemorating, by the unveiling of a memorial plaque to William Froude, as nearly as possible to the site of the first ship-model towing tank, which he constructed there in 1870-71. There was, of course, a programme of technical papers to be discussed, interspersed with sundry visits and social events, but Froude, his work, and his family associations with Torquay and district set the dominant note for the proceedings, and the unveiling of the memorial was the first item in the programme for the meeting.

The memorial consists of a bronze plaque bearing a portrait of William Froude and an inscription, which is reproduced below, and is mounted in a small alcove constructed in the wall of the garden which now occupies the site of the original tank. It faces Seaway-lane, which leads to Chelston Cross, where Froude lived from 1867 until his death in 1879, and is within ten minutes' walk of the main railway station of Torquay, and of the Grand Hotel, which was the Institution's headquarters for the meeting.

VISCOUNT RUNCIMAN'S ADDRESS

The unveiling ceremony was performed by the President, Viscount Runciman of Doxford, and was attended by the Mayor (Councillor W. H. White) and the Mayoress of Torquay, by Rear-Admiral L. N. Brownfield, C.B., C.B.E., Admiral Superintendent of H.M. Dockyard, Devonport, and by Mr. W. Froude, Miss Mary Froude and Miss Beatrice Froude, grandchildren of William Froude. In a short address to the company, before unveiling the memorial, Lord Runciman said:

"We are here to-day to do honour to the memory of William Froude. He was a modest genius if ever there was one, and overshadowed in the public eye by his brothers, Hurrell, of the Oxford Movement in the Church of England, and James Anthony the historian; but, though he was little known outside the professional circle of naval architects and shipbuilders and, even to-day, his name is seldom heard except among those who build and design ships, the effect of his work is felt in the everyday life of this island, and, indeed, of many other lands to a degree of which very few of their inhabitants are aware. His pioneer work in using models of ships in a tank as an aid and test for the design of hulls has led more, perhaps, than any other single development in the methods of naval architecture to progressively improving the safety and economy of hull forms, so that not only seamen and all who travel by sea, but every one of us who imports or exports or wears or uses or eats anything that is carried by sea, is to some degree in his debt.

INTERNATIONAL SUPPORT

"William Froude was an Englishman and a Devon man at that, but his work was international. It was, therefore, a happy suggestion made by the Tank Superintendents, who are Froude's successors in ship-model research, at their Sixth International Conference in Washington three years ago, that some permanent memorial should be erected to him in his native country. Learning of this, the Institution of Naval Architects readily agreed to support the proposal and give effect to it.

"This, then, is why we meet in this unusual setting of a Devonshire country lane; for it was here, a few yards from where we are standing, that Froude built the first ship-model experiment tank in the world 84 years ago, in 1870, and here were carried out for the British Admiralty those first experiments with scale models of ships from which the shipbuilders of the world have since reaped such benefit.

"Like most pioneers, Froude was faced with considerable scepticism at the time he made the first preparations for undertaking model experiments, and with some professional opposition as to the value of the results to be obtained from them, but he had influential supporters, and it is to the credit of the British Admiralty that they were convinced of the value of his work and authorised him to go ahead. He accordingly obtained official support and financial backing; very modest financial backing, but backing nevertheless.

"In this assembly of professional talent there is no need for me to elaborate on the many other scientific and technical developments which have evolved from Froude's memorable activities. I think, too, that most of you know the Institution of Naval Architects has thought it appropriate to commemorate Froude's memory by publishing all his technical papers in one volume, a work which is now in preparation and nearing completion. That volume will also include interesting notes on Froude's life and work, and help us to appreciate his real status.

"Living at his home at Chelston Cross, just along the road here, William Froude acquired some adjoining land on this side of the road and laid out his tank. One end of it was adjacent to this Memorial and the tank ran diagonally across what is now Dr. J. R. Pooler's garden and house. May I say how grateful we are to Dr. Pooler for surrendering a piece of his frontage for the site of the Memorial, and at the same time express the hope that, in years to come, this erosion of his property may, in fact, enhance its value. There could be no more fitting place for the Memorial."

After welcoming the members of the Froude family who were present, and expressing the thanks of the Institution to the Mayor and the Borough Council for the interest they had shown and the assistance they had rendered in making possible the erection of the plaque, and to Mr. T. H. Kerslake, of Cockington, Torquay, who had designed and set up the Memorial, the President drew aside the Union Flag which had veiled the plaque.

FROUDE'S SUCCESSORS

Professor H. F. Nordstrom, representing the International Conference on Ship Hydrodynamics, said that, as the President had remarked, the International Conference might be regarded as an association of Froude's successors, for most of their members were connected in some way with the ship-model experiment tanks in different parts of the world, which were carrying on his work. He was the pioneer of the ship-model technique.

The international importance of William Froude's work could not be over-estimated, for human progress had been materially advanced by his fundamental achievement. It was equally true to say that the importance of the work carried out in the various experiment tanks in accordance with Froude's principles to-day was fully acknowledged by all naval authorities, and by all shipbuilding and shipping circles. The Conference that he represented appreciated very much the initiative taken by the Institution of Naval Architects in erecting the memorial. It provided a meeting point at the birthplace of the founder of their science.

Wreaths and chaplets were then laid at the foot of the memorial plaque by Lord Runciman on behalf of the Institution of Naval Architects, by Professor Nordstrom on behalf of the International Conference on Ship Hydrodynamics, and by the Mayor of Torquay on behalf of distinguished residents and the Aldermen and burgesses of the Borough.

The plaque bears at the top the head of William Froude, and the inscription:

"William Froude, M.A., LL.D., F.R.S., 1810–1879." Beneath it are the words:

"William Froude was born in 1810 at Dartington, Devon, and lived at Chelston Cross from 1867 until his death in 1879. His outstanding contributions to the science of naval architecture brought him world-wide renown. He was the pioneer of ship model research, and in 1872 built the first experiment tank in the world on this site for the Admiralty, for whom his main work was carried out. This memorial was erected in 1954, by naval architects of many countries as a grateful tribute to his genius."

After the unveiling ceremony, the members and their friends returned to the Grand Hotel, where an informal luncheon was held, at which the Mayor and Mayoress were the principal guests. They then proceeded to the Electric Hall, adjacent to the Town Hall, for the opening session of the programme of technical papers.

TECHNICAL PAPERS

These were six in number, two being taken during the afternoon of September 21, two on the following morning, and the concluding two papers on the morning of Friday, September 24. The papers, in order, were on "The Admiralty Experiment Works, Haslar," by Dr. R. W. L. Gawn, O.B.E., R.C.N.C.; "B.S.R.A. Resistance Experiments on the Lucy Ashton. Part III: The Ship-Model Correlation for the Shaft-Appendage Conditions," by Mr. H. Lackenby, M.Sc.; "The Measurement of Power," by Dr. T. W. F. Brown; "Scale Effect Experiments on 'Victory' Ships and Models. Part I: Analysis of the Resistance and Thrust Measurements on a Model Family and on the Model. Boat D. C. Endert Jr." by Professor Dr. Ir. W. P. A. van Lammeren, Dr. Ir. J. D. van Manen and Ir. A. J. W. Lap; "Experiments with a Low-Drag Hydrofoil," by Mr. R. L. Townsin, B.Sc.; and "Side Launching of Ships, with Special Reference to Trawlers," by Mr. D. J. Doust, B.Sc.

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RADIO FOR SHIPS' LIFEBOATS

The Marconi International Marine Communication Company, Limited, Chelmsford, Essex, have produced a fixed transmitter/receiver equipment for permanent installation in larger-size lifeboats. Known as the "Salvare" it can be operated by following the numbers painted on the panel and does not need a skilled operator. Power is obtained from a 24-volt battery charged by a generator on the lifeboat's engine. There is an automatic keying system for either "alarm" or "distress" signals. The aerial can be either mast-mounted or suspended from a kite.

The Institution of Naval Architects Autumn Meeting

THE ADMIRALTY EXPERIMENT WORKS

SHIP-MODEL TANKS AT HASLAR AND DUMBARTON

The President took the chair at the opening technical session of the Institution of Naval Architects Autumn Meeting (referred to on page 423) and called on Dr. R. W. L. Gawn to present his paper on the Experiment Works at Haslar, of which he is Superintendent.

Dr. Gawn's paper, as he explained in briefly presenting it, was prepared as a tribute to William Froude, whose initial equipment was transferred to Haslar after his death, and whose work, mainly undertaken for the Admiralty, had been continued at Haslar ever since—for many years under the direction of his son, Robert Edmund Froude. The scope of the work carried out at Haslar had been greatly widened to meet the exacting requirements of the modern Navy, but the methods employed rested still on the secure foundations that Froude had laid. Formerly, the investigations were largely concerned with propulsion, but that item had become much more comprehensive, and seaworthiness, manœuvring, vibration and other qualities were also fully considered. The original ship tank at Haslar was now supplemented by another, of greater size and carriage speed, and there were also two cavitation tunnels and other laboratories. The manœuvring of self-propelled models, about 20 ft. long, was investigated in a deep open-air lake, the motions of the models being photographically recorded. Experiments on the interaction between vessels were important in developing the technique of refuelling at sea. The paper concluded with an appreciation of the work of R. E. Froude, who was responsible for the design of the original establishment at Haslar and was Superintendent until he retired in 1919; and of his successor (Dr. Gawn's predecessor) M. P. Payne, under whom the establishment was enlarged by the addition of No. 2 Tank.

In the course of his presentation of the paper, Dr. Gawn exhibited the first propeller model tested in the Admiralty Experiment Tank, Torquay, in 1873. It was made for the model of a single-screw corvette, H.M.S. Encounter. A film was also shown which depected some of the activities of the Admiralty Experiment Works at Haslar. It illustrated the preparation of propellers, the testing of a propeller in the cavitation tunnel (exhibiting very high cavitation), anchors and their behaviour in use, turning tests with a self-propelled model in the tank, the testing of towed models at high speed, etc. Dr. Gawn's slides included a picture of the tank at Torquay; a square-paper ruling machine made by William Froude, and still in regular and constant use at Haslar; and portraits of William and R. E. Froude.

The President thanked Dr. Gawn for the interesting way in which he had presented his paper, and not least for the portraits of the Froudes, father and son. He then invited Sir Maurice Denny, Bt., K.B.E., to open the discussion.

DISCUSSION

Sir Maurice Denny said that, by the kindness of the President, he would give a brief summary of the work of the experiment tank in Dumbarton, the oldest commercial testing tank in the world; in fact, it antedated Haslar by a few years. He would confine it to a survey of the first 25 years' work, partly because a quarter of a century is a kind of standard period, and partly because, by that time, John Brown and Company had just built their tank at Clydebank, and Dumbarton, therefore, was no longer unique. It was the first time that such a record had been made public, and it would be the last. His uncle, William Denny, a man of great imaginative foresight and restless energy, on learning of Froude's early work, immediately visited Torquay and returned fired with the tremendous possibilities of ship-model testing. The construction of the tank was immediately begun, and in 1882 it became an effective department of the shipyard. By modern standards it was small, having only been slightly enlarged since its formation.

Though the first recorded model experiments had been completed in 1883, for the first four years the tank was of little practical value to the firm. As the work had to start absolutely from scratch, it was essential to collect basic data. A large accumulation of measured-mile trial records was at hand and therefore the first three to four years were mostly spent in testing models of vessels which had been subjected to such trials. The year 1883 records tests of 13 models, this figure rising steeply to 36 in 1890. Even during the first year of the tank's existence, when no model shaping machine was yet available, the time required for making a 12-ft. model, testing for resistance and calculating the ship effective horse-power took only six working days.

In the 'eighties and early 'nineties, when paddle vessels remained close rivals to screw ships, the tank was of the greatest value in determining by model tests the correct position of the paddle wheel in relation to the wave formation along the hull.

Systematic model series research, along with the gathering of other test data during these first four years, bore their first practical fruit in 1887, when the Belgian Government asked for tenders for two fast passenger paddle steamers to improve their Ostend-Dover service. A thorough investigation was carried out at the tank on three models, with variations, for a vessel 300 ft. by 35 ft., the dimensions suggested by the owners. It appeared that no more than 19½ knots could be guaranteed. At that time, beam was generally regarded as detrimental to speed; but, encouraged by data gathered from series models, new models were put in hand with the beam increased to 38 ft., the block coefficient being, of course, correspondingly reduced. As a result, a speed of 20¼ knots was offered, and the firm secured and fulfilled the contract.

In 1887, also, the first experiments in waves were carried out in order to measure the increase in resistance. By modern standards the wave-maker was rather a crude affair, consisting of a stout wooden board extending over the whole width of the tank and operated manually by four men to the period of a pendulum; but it worked. As far back as 1888, the firm became aware that the paint on the under-water hull had much influence on the performance of a ship, and for that reason surface friction experiments were carried out with different types of paint, and comparisons established. A few years later, the effect of a roughened hull was studied by progressively increasing the grain of the sanded under-water part of the model.

Long before the days of modern wind-tunnel tests an attempt was made, in the same year, to record the wind resistance of a fully-rigged ship. A model of a passenger ship complete with all superstructure and rigging was made, placed in a swinging bed at the forward end of the dynamometer carriage, and the wind resistance measured at various speeds with the bottom end of the swinging bed coupled to the dynamometer.

Although valuable work had been done at the Dumbarton tank in connection with paddle steamers, its attention and work gradually switched to the problems of screw propulsion as this became more generally adopted. Already in the late 'eighties a propeller dynamometer was available, with the propeller or propellers driven by an endless cord.

The advent of the turbine steamer, in which connection he recalled the pioneer King Edward for Clyde services, greatly increased the scope of the tank work in view of the necessity to test propellers working at very high revolutions. The turn of the century made new demands on the skill and resources of the tank staff, when Sir Thomas Lipton commissioned the firm to build a new yacht (Shamrock II) to the design of the late G. L. Watson of Glasgow. Both owner and builders agreed that, to have the best possible chance of winning the America's Cup in the 1901 races, the new vessel should be tank-tested. These experiments were the first of their kind ever attempted on a large and systematic scale. In designing the new challenger, a speed of 11 to 12 knots had to be the target, which meant, for a vessel of 90 ft. on the nominal water line, a speed/length ratio of 1·2.

It was decided at the tank to begin with models of Valkyrie and Shamrock I, the last two unsuccessful Cup challengers. This was done for two reasons, firstly to find a basis for comparison as a guide to the new vessel, and secondly because changes could be made to those models in a systematic manner so that variations of compromise could be tried out. The tests consisted of ordinary resistance experiments in line of motion and also measurements of both resistance and side forces with the models at various angles of yaw and heel appropriate to their various racing conditions. Before the Shamrock II form was finally decided on, eleven different models were made, each of which had various alterations, making in effect 100 different forms tested. Shamrock II unfortunately lost in the three races, though only by a small margin, but according to New York opinion she was the better boat and would have won if better handled.

AN EARLY HELICOPTER

In tracing the history of the Dumbarton tank over its first 25 years of existence, mention ought to be made of the fact that in January, 1905, the Superintendent, E. R. Mumford, produced a memorandum in which he expounded his conviction that flight in air was possible by means of propellers alone, without any supporting plane surfaces. To support his theory he had constructed an exhaustive set of curves of thrust and power for varying diameter and revolutions, both for water and air. It was finally decided to test the theory in practice.

The first machine, of bamboo framework with six propellers, each 25 ft. in diameter, so geared as to occupy the minimum of space, was fitted with a 40-h.p. French engine, which proved unsatisfactory. Later, a light metal framework was produced and a new British engine procured, but in those early days of power flight it was very difficult to find an engine which would give even that low power output for any length of time. Tests with a model had shown that the machine had complete stability and would fall gently in the event of the engine failing in mid-air —a likely contingency in those days.

After many vicissitudes, trials began. The machine rose from the ground, but was restrained from free flight pending adjustments. Unfortunately, the advent of the first World War put a stop to all further development, and by the end of the war the machine had disintegrated. Nevertheless, it can be claimed that this machine was the first helicopter ever to leave the ground under its own power.

"With these few remarks," Sir Maurice concluded, "I close a brief record of great adventure. This morning we have honoured the memory of William Froude, a master mind, and I think it fitting at this time that I should pay tribute to the name of William Denny, another remarkable man, who was Froude's first disciple."

The remainder of this discussion and the discussions on the other I.N.A. papers (the titles of which are given on page 423) will be reported in subsequent issues of ENGINEERING.

BRITISH ASSOCIATION MEETING

FLOODS AND COAST EROSION: DRAWING A CYLINDRICAL SHELL

Continued from page 390

For Monday morning, September 6, a joint discussion was arranged for Session A with Section E (Geography) on the subject of Floods and Coast Erosion. The chair was taken by Professor A. Thom, one of the vice-presidents of Section G. The subject was introduced by Mr. J. Duvivier, who read a paper entitled "The Protection of Coastal Lands Against Flooding and Erosion," which is published in last week's and this issues of ENGINEERING. It dealt with the design of protective works, the formation and movement of beaches and made special reference to the floods of January, 1953. This paper was followed by one by Mr. W. Vaughan Lewis entitled "Nature's Method of Coastal Protection," which reported an examination of the action of the sea in forming beaches, such as the pebble beach at Chesil, which protect parts of the coast from erosion. Both papers were presented by their authors and the two were then discussed together.

LAND RECLAMATION BY VEGETATION

Dr. E. H. Chater, of the Botany Department of University College, Aberystwyth, opened the discussion by observing that, although the movement of wind and water was held to be responsible mainly for destructive forces, on many coasts the new land formed by natural causes was, in area, of the same order as that lost by erosion. Moreover, apart from shingle beaches the formation of new land was principally the result of vegetational growth. The effect of vegetation was to promote periodical accretion by the sedimentation of wind-borne sand or water-borne silt, and also to stabilise the terrain so formed. The botanist was therefore concerned in the problem of coastal erosion, since by studying the relation between the plants growing in these habitats and their environment he might sometimes be able to indicate the manner in which vegetation could be exploited to best advantage.

There were three main categories of natural vegetation that might be employed on coastal lands and these were native respectively to the sand dune, the shingle beach and the salt marsh. Different problems applied in each case but some of the underlying principles were the same. Typical of the processes involved was that which took place in the salt marsh; any vegetation which established itself on tidal silt tended to retard the movement of the water and so cause a more rapid sedimentation of silt, which remained as a fresh deposit when the tide retreated.

The effect of plants in promoting sedimentation depended on their height and density, but in general the yearly rise in level recorded in salt marshes round our coasts was of the order of 3 mm. to 10 mm. A particularly successful species for this purpose was rice grass or *Spartina Townsendii*, and for best results this was sown in the neighbourhood of high-water mark at neap tides, thus ensuring that it was covered by high water at every tide. It had been planted extensively in Holland for land reclamation and had increased vertical accretion of ground by approximately four times.

The salt marsh was especially useful in districts where reclaimed land already existed. Such land was usually protected by earth walls, and a salt marsh to the seaward side of these left their bases less exposed to wave attack. The raising of marsh levels in this way led, however, to other problems, and increases in the number of Spartina areas in Holland had, the Belgian authorities claimed, caused a 1 ft. rise on the wharves at Antwerp.

The action of marram grass on sand dunes was similar to that of Spartina in the salt marsh, but sedimentation was produced in this case by hindrance to the movement of air. Marram also served to stabilise the ground and induced certain soil changes enabling other species to establish themselves. At the seaward faces of dunes subject to wave wash, however, marram was unsuitable, and instead sea couch grass or lyme grass was employed; even when dead and beaten flat lyme grass afforded protection, since it served in effect as a natural thatch.

Among the plants most suitable for use on shingle was the shrubby sea blite, and in districts where a shingle spit was backed by marsh land it was of considerable value, acting as a stabiliser and tending to prevent landward creep. It required, however, a supply of organic matter, and this was only provided when high tides reached the marsh and brought back organic materials to the drift line. When the marsh was reclaimed and the periodic entry of the sea prevented, the beaches became sterile and their level was reduced by storm action; subsequently, the sea would break into the reclaimed land behind the beaches. This had happened on parts of the Norfolk coast and also near Winchelsea.

The next speaker was Dr. H. A. Cole, Director of the Shellfish Research Station, Burnham-on-Crouch, who gave examples of the importance of coastal erosion and protection to the zoologist.

Professor A. J. Guilcher said that although France had not had such disastrous floods as those which occurred along the North Sea coasts in 1953, there had been some difficulties in 1950 caused by a loss of sand in the Deauville area in Normandy, where mud which had previously been hidden by the sand suddenly appeared all along the beach.

Besides destruction from flooding and coast erosion it sometimes happened that sedimentation gave rise to flooding, and he had recently had an opportunity of studying such a phenomenon in French West Africa. In that country there were extensive coastal marshes, originally covered with mangroves, and now used for rice production. In one such area it had become more and more difficult to keep the rice fields in a good condition because the tidal creeks had been filling with soft mud and hence the water could not escape during the rainy season but lay in the rice fields, too deep to permit cultivation.

A study of the region, both from the air and on the ground, had shown that the filling of the creeks was related to erosion around the coast. There was a muddy shore which was cut back by the waves and that mud which had formerly been deposited in the tidal marshes was now being eroded and taken into suspension in the water. Now that the cause of flooding had been found, it was possible to protect the rice fields by diverting the water into other estuaries, by means of small dams.

That was just one example of the connection between geographical studies and engineering works. Unfortunately, in France there was often no collaboration between engineers and geographers.

The discussion was continued by Dr. A. P. Thurston, M.B.E., who spoke of a wall which he had built and which had survived the severe East Coast storms. In its construction he had allowed for coastal drift not only at low tide but also at high tide; many walls, he said, had been damaged by the side drift of waves at full tide. It had also been insufficiently appreciated, he maintained, that water accumulated in the North Sea when the wind blew from the north-west and could not escape quickly enough through the Channel. Consequently, if this occurred at spring tide, there was bound to be an excessive rise in the water level.

Dr. Thurston recommended that the edges of cliffs be drained and that it should be forbidden for people to approach cliff edges, especially with vehicles of any kind. Water which soaked into cliffs, causing them to crumble, frequently contributed to their destruction. The slope of the strata and the nature of the layers were also important considerations, since certain materials when they became wet acted as a lubricated surface and, if the strata sloped seaward, would rapidly precipitate cliffs into the sea.

The following speaker, Mr. E. O. Giffard, M.B.E., asked Mr. Duvivier if any advantage would be gained by the erection of a wave-breaking obstacle on the beach a little to seaward of the main wall. Would such obstacles, concrete or otherwise, be successful in breaking a wave before it struck the wall?

In his reply, Mr. Duvivier said that wave-breaking obstacles had in fact been provided at a number of places. Along the South Coast east of Hastings and along the Sussex Coast in the vicinity of Shoreham wave screens had been erected half-way down the beach, but, although he had studied them carefully, he had come to the conclusion that a wave screen was capable of nothing that could not be achieved more efficiently and cheaply by a breastwork or sea wall, constructed above high-water mark and acting in conjunction with groynes.

The meeting ended with a vote of thanks to the speakers proposed by Professor J. A. Stears, Professor of Geography, Cambridge University, who said that coastal problems were clearly by no means the concern of one branch of science alone. Speakers during the morning had shown evidence of the close co-operation existing between engineers, geographers and ecologists and, although each regarded the coast from a different point of view, it was by their collective contributions to a free discussion that the problems of coast erosion were most likely to be solved.

THE MECHANISM OF A SIMPLE DRAWING OPERATION

The first item on the programme of Session B on Monday morning, September 6, was a paper by Professor H. W. Swift entitled "The Mechanism of a Simple Drawing Operation," which reviewed some investigations on the drawing of a cylindrical shell from a flat circular blank and included a proposal for a test to compare the drawability of different materials. Professor Swift presented his paper (published in this issue, abridged) and at its conclusion the chairman, Dr. Willis Jackson, F.R.S., in inviting discussion, questioned whether "drawing" was the most appropriate word to describe the operation referred to. His own view was that it could best be described as deep-pressing. To this comment the author replied that the term drawing was an industrial one and he felt it was more specific than pressing. Drawing implied a two-dimensional system of strain. The first kind of drawing was wire-drawing, and why this operation was referred to as "drawing" could easily be appreciated. Then, when tubes began to be reduced in diameter, the operation was naturally called tube-drawing. The processes occurring in tube-drawing were similar to those in the second or third stages of drawing a cylindrical cup. He thought that was why the term "drawing" came to be used.

Mr. G. Murray, who said he had been associated with Professor Swift on committees for many years, called attention to the great amount of work involved in making a clear exposition of a deep-drawing operation. Formerly, no teacher in a technical school could have taught his students much about the technicalities of deep drawing, but with the aid of a paper such as that of Professor Swift there was a good chance of getting better tool design than before. Deep drawing and similar operations had been built up over many years by practical trial and error, but there now seemed to be a chance of having tool designs more in line with the theory of drawing than had been the case in the

past. As an example of the lack of knowledge of deep drawing, Mr. Murray mentioned that he had visited a firm normally engaged in iron casting who proposed to make a simple flat-bottomed cup by drawing instead of by casting. They had, however, not realised that the metal thickened up and had left no clearance between the punch and the die; they were grateful to him for calling attention to the need for making such allowances. He finally congratulated Professor Swift on having made the point that there was no single test for deep drawing.

Replying to Mr. Murray, Professor Swift said he did feel that one discovery which had assisted in giving a better understanding of the problem had been the effect of bending under tension. It had not been realised that if material were being bent plastically and there were any tension in it, it was bound to thin. With regard to the conclusion that there was no single test for drawability he would not like that idea to reach the public in such a way that they would give up the practice of testing sheet metal. Although there was no single test for drawability, it was agreed that there was a procedure for testing which covered the different types of drawing operations. He hoped it would be available to industry before very long, although the procedure must be varied according to whether the material to be tested was to be used for deep drawing or other drawing processes.

Dr. J. D. Campbell asked if the speed of drawing affected the properties of the material or the manner in which it behaved; to which Professor Swift replied that the effect of the speed of drawing was tied up with the question of lubrication; it was not possible to vary speed and keep the lubrication constant. A rather complicated investigation had been made and the first fruits of it were shown in the diagrams towards the end of the paper. The full effects of speed were not known, but over the range likely to be used, say from 5 to 60 strokes of the press per minute, there was no great difference. The tendency was for the punch load required for the draw to increase with the speed.

The chairman here remarked that while the lubricants mentioned in the paper might be appropriate, it was singularly difficult to apply quantitative criteria. It was conceivable, however, that a mineral oil used in the process would take a certain pressure. Professor Swift replied that the practice was to apply lubricant in excess to both sides of the work. If $\frac{1}{4}$ in. thickness of lubricant were applied, all but a very small residual part of the lubricant would be squeezed out after only a fraction of a second. The purpose of the paper was to give a general view and, in particular, to show that the most likely type of lubricant for deep drawing, where the pressures were very high, of the order of 2 tons per square inch, was not basically an oil but something solid. However fast the drawing operation, the initial application of a $\frac{1}{4}$ in. of oil or grease would have no more effect than oil 0·001 in. thick.

Mr. J. C. Wightman asked whether, in view of its constantly varying punch speed, the use of a crank press had not rather complicated the experiments described. Professor Swift replied that the crank press had not complicated the experiments, but it had complicated the discussions to some extent. Two presses had been used in the experiments, one of the hydraulic type having a practically uniform punch speed of up to $3\frac{1}{2}$ in. per second and the other the crank press. It was felt that, from the point of view of industrial interest, the results would be more readily acceptable if the work were carried out in the type of press most commonly used in industry. Since the effect of speed over quite a wide range was small, it was possible to disregard the argument that the hydraulic press should have been used because its action was more constant than that of the crank press.

This completed the discussion and after a vote of thanks to Professor Swift had been proposed by the chairman, and duly carried, the meeting was adjourned.

To be continued

BOOK REVIEWS

The Application of Results of Research. Compiled and edited by VERA CONNELL, in collaboration with the British Commonwealth Scientific Offices, London. *Butterworths Scientific Publications*, 88 *Kingsway, London, W.C.*2. (21*s.*)

This book is concerned primarily with the application of the results of research carried out in Government establishments in the British Commonwealth. The complexity of the problem is revealed by the different methods adopted by the various countries, and still more by the changing climate of opinion which occurred even during the assembly of information and subsequent writing of the report on which the book is based. The report was first presented to the British Commonwealth Scientific Conference held in Australia in 1952, and it was significant that the Prime Minister of Australia, the Rt. Hon. R. G. Menzies, when opening the Conference, made this subject the main theme of his address. At this Conference, two committees were set up to consider the application of the results of research in the fields of industry and agriculture respectively. The results of their deliberations, together with more recent contributions from the countries represented, are included in the present publication.

The first part of the book is a review of the methods adopted and obstacles encountered in translating the results of "directed basic research" into industrial practice. The second, occupying about five-sixths of the book, is a detailed account of the organisation of Government research institutions in the Commonwealth countries and the methods employed to encourage the utilisation of their research results. The editor has included a description of some novel methods employed in the United States, particularly by the Tennessee Valley Authority. As she rightly points out, it is regrettably true that it took two world conflicts to stimulate and accelerate the practical application of much basic research. Why, indeed, is it possible to obtain a much more rapid translation of research results during hostilities than in peace-time? It would seem that the fear engendered by war is a greater stimulant than commercial competition, or at least national aims and requirements are clearer in war than in peace.

In view of the limitations on publication imposed in war-time for security reasons, it has become increasingly clear that publication (including the use of films, radio, exhibitions, etc.) is not enough to ensure the assimilation of ideas and their practical application. Information on some of the methods used to close the gap between publication and application is given in two chapters dealing with conventional and special methods, the latter covering the use of operational-research methods, information services, surveys, committees, extension services and the use of industrial liaison officers. There is clearly great scope for an extension of work of this kind, by firms and by Governments.

When the right conditions are created, as this book shows, the obstacles can be overcome and an equally rapid application of research to industrial practice achieved in peace as in war. As examples, one is referred to the Tennessee Valley Authority's work and to certain notable agricultural developments. Both these applications illustrate the importance of ensuring the co-operation, at an early stage in the introduction of a new development or technique, of those most likely to benefit, whether it be the farmer, farm labourer, industrialist or industrial worker. The human factor cannot be ignored; personal contacts must be fostered and new discoveries must be presented in language that can be understood by those who will be responsible for their practical application. Above all lies the responsibility of directing a country's research and industrial effort in the directions likely to yield increasing returns, making the best use of its natural resources and native skill. Much remains to be done, but this report shows that intensive efforts are being made to bridge the gap.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Water Steriliser. HANOVIA LTD., Bath-road, Slough, Buckinghamshire. Ultra-violet steriliser for water supplies. Tested at National Institute for Research in Dairying, Reading (Report No. 54 C/2). Consumes 2 kVA for water flows of 2,000 gall. per hr. Pamphlet giving dimensions and details.

Electric Overhead Travelling Cranes. PATERSON HUGHES ENGINEERING CO. LTD., Bedford House, Bedford-street, London, W.C.2. Specialists in the design and manufacture of electric overhead travelling cranes from the single-girder hand crane to the more complex heavy-duty lattice-girder three-motor installation. Newly produced Section 4 of their catalogue illustrating typical installations.

Coal Cutter. BRITISH JEFFREY-DIAMOND LTD., WAKEFIELD, YORKS. Twin-jib "Ace" coal cutter. Top jib with 3 ft. undercut and bottom jib for 6 ft. undercut, each using Hoy Multipic chain. Pamphlet describing prop-free front working in the Dunsil Seam at Frickley Colliery, North-Eastern Division.

Water-Control Gates. RANSOMES & RAPIER LTD., Waterside Works, Ipswich. Stoney sluice gates for controlling water at irrigation and flood-prevention barrages. Illustrated leaflet depicting gates installed by the company at major schemes in many parts of the world.

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BOOKS RECEIVED

Design of Concrete Structures. By L. C. URQUHART, C. E. O'ROURKE and G. WINTER. Fifth edition. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (7·50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (60*s.*)

Industrial Stoichiometry. Chemical Calculations of Manufacturing Processes. By W. K. LEWIS, A. H. RADASCH and H. C. LEWIS. Second edition. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (7·50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (60*s.*)

Lightning Protection for Electric Systems. By EDWARD BECK. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (6·50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (52*s.*)

Heat Transmission. By WILLIAM H. MCADAMS. Third edition. *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (8·50 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (68*s.*)

"Business" Directory of Office Equipment and Appliances. Edited by ROBERT SPARK. *Business Publications, Limited*, 180 *Fleet-street, London, E.C.*4. (40*s.*)

British Standards Institution Annual Report, 1953-54. *British Standards Institution*, 2 *Park-street, London, W.*1. (5*s.*)

Corrosion: Problems and Prevention in the Chemical and Petro-Chemical Industries in the U.S.A. Technical Assistance Mission No. 130. *Organisation for European Economic Co-operation*, 2 *Rue André-Pascal, Paris* (16*e*). (420 francs); and *H.M. Stationery Office, Kingsway, London, W.C.*2. (8*s.* 6*d.*)

Wave Motion and Vibration Theory, Vol. V. Proceedings of the Fifth Symposium in Applied Mathematics of the American Mathematical Society. Published for the American Mathematical Society by *McGraw-Hill Book Company, Incorporated*, 330 *West* 42*nd-street, New York* 36, *N.Y., U.S.A.* (7 dols.); and *McGraw-Hill Publishing Company, Limited*, 95 *Farringdon-street, London, E.C.*4. (56*s.*)

Statistics of National Product and Expenditure, 1938, 1947 to 1952. *Organisation for European Economic Co-operation*, 2 *Rue André-Pascal, Paris* (16*e*). (500 francs); and *H.M. Stationery Office, Kingsway, London, W.C.*2. (10*s.*) (See Weekly Survey, ENGINEERING, September 24.)

The Finance Act, 1954: A Summary for Engineers. *Engineering Industries Association*, 9 *Seymour-street, London, W.*1. (2*s.* 6*d.*)

Institute of Metals Autumn Meeting (*concluded from page* 394)

THE CONSTITUTION OF TITANIUM ALLOYS

The last technical session of the Swiss Autumn Meeting of the Institute of Metals was held in Zürich on the morning of Friday, September 10. Dr. Maurice Cook occupied the chair and the purpose of the session was to hold a discussion on "The Constitution of Titanium Alloys" based on eight papers published in the *Journal* of the Institute. Mr. E. A. G. Liddiard, director of research, Fulmer Research Institute, Stoke Poges, introduced the papers as *rapporteur*.

The first was entitled "The Structure of the Titanium-Tin Alloys in the Range 0 to 25 atomic-per cent. Tin." The author was Dr. H. W. Worner, of the Baillieu Laboratory, University of Melbourne, Australia. He stated in his paper that he had conducted his investigation by metallographic and Debye-Scherrer X-ray diffraction methods and, as a result, a partial phase diagram had been established. Tin depressed the freezing point of titanium and there appeared to be a eutectic point in the vicinity of 17 at.- per cent. tin at about 1,550 deg. C., the solid constituents involved in the eutectic transformation being a solid solution of tin in β-titanium and a phase, designated γ, based on Ti_3Sn. The solid solubility of tin in α-titanium was just over 10 at.-per cent., and it varied only slightly in the range 700 deg. to 880 deg. C. The solubility of tin in β-titanium increased from 7·5 at.-per cent. at 885 deg. C., to approximately 10 at.-per cent. at 1,100 deg. C.

"The Re-investigation of a Nickel-Titanium Alloy and Observations on $\beta/(\alpha + \beta)$ Boundaries in Titanium Systems" was the title of the second paper, which was by Dr. A. D. McQuillan, of the University of Birmingham. The author stated that he had considered the causes of disagreement in reported $\beta/(\alpha + \beta)$ boundaries in titanium-rich systems. The examination of a 2·4 at.-per cent. nickel-titanium alloy had shown that the deposition of α and β could occur extremely rapidly by a process of nucleation and growth. It was concluded that delay in the quenching of alloy specimens was the most probable cause of error.

The third paper was upon the subject of "The Free-Energy Diagram of the System Titanium Oxygen." It was a communication from the National Physical Laboratory by Dr. O. Kubaschewski and Mr. W. A. Dench, who stated that titanium-oxygen alloys of various compositions had been equilibrated with calcium, magnesium, or barium mixed with its respective oxide, in bombs of titanium or steel at temperatures between 950 deg. and 1,380 deg. C. In other words, the experimental method had involved heating a sample of titanium containing oxygen for some time, at a known temperature, with calcium, magnesium or barium. After leaching, the concentrations of oxygen in the titanium had been determined by the vacuum-fusion method. The analytical data, the free energies of formation of the oxides of the alkaline-earth metals, and the heats and entropies of formation of the titanium oxides had been used to construct the free-energy concentration curves of the titanium-oxygen system at 1,000 deg. and 1,200 deg. C.

TITANIUM-SILVER ALLOYS

The fourth paper dealt with "The Structure of Titanium-Silver Alloys in the Range 0-30 at.-per cent. Silver" and was by Dr. H. W. Worner. He stated that he had employed metallographic and X-ray diffraction methods to determine a partial phase diagram between 0 and 30 at.-per cent. silver, in the temperature range 650 deg. to 1,100 deg. C. The addition of silver caused only a small depression of the $\alpha \rightleftharpoons \beta$ transformation temperature in titanium. This was in striking contrast to the marked depression caused by the majority of alloying elements which had atomic radii close to that of titanium. Quenching from the β-solution field caused hardening of the alloys, the effect being of the order of 50-90 diamond-pyramid hardness units for alloys in the range 6·5-22·3 at.-per cent. silver.

"A Re-determination and Interpretation of the Titanium-Rich Region of the Titanium-Chromium System" was the subject of the fifth paper, which was by Mrs. M. K. McQuillan, of Imperial Chemical Industries, Limited, Metals Division, Birmingham. She stated that conflicting evidence in the literature had led to a re-determination of the phase boundaries in the composition range 0-14 at.-per cent. of chromium, using techniques designed to eliminate all likely sources of error. The eutectoid temperature had been found to be much lower than hitherto supposed. The difference between the present and previous micrographic results had been found to be due to insufficiently rapid quenching in the earlier experiments.

DETERMINING LIQUIDUS POINTS

Two "Methods for Determining the Liquidus Points of Titanium-Rich Alloys" or of other metals which were too reactive for the use of conventional thermal analysis, were described in the sixth paper, which was by Dr. W. Hume-Rothery, O.B.E., F.R.S., and Mr. D. M. Poole, of the University of Oxford. The authors stated that in one method the alloy was first prepared in an argon-arc furnace, and small specimens, in titanium containers, were heated to successive temperatures and quenched. Microscopical examination would then usually permit distinction between specimens quenched from the totally-liquid or partly-liquid field, and the liquidus point of a titanium-nickel alloy had been determined as lying within a temperature bracket of 4 deg. C. In the second method, specimens of varying composition were quenched from a fixed temperature in a container, the composition of which lay on the solidus curve at the temperature concerned. The liquidus point was thus determined by a composition bracket, and the totally and partly-liquid specimens were distinguished both microscopically, and by the fact that the container was attacked much more rapidly when the totally-liquid field was reached.

"Note on the Constitution of the Titanium-Gold System in the Region 0-6 Atomic-per cent. Gold," was the title of the seventh paper and it was by Mrs. M. K. McQuillan. She stated that micrographic examination of quenched specimens had shown that the titanium-gold system was of the eutectoid type. The eutectoid temperature had been found to be 830 ± 2 deg. C. and the eutectoid composition $4·4 \pm 0·2$ at.-per cent. gold. The compound which was formed, together with the α solid solution, by eutectoidal decomposition of the β phase, had been shown by X-ray diffraction methods to be Ti_3Au. The maximum solubility of gold in α-titanium was approximately 3 at.-per cent.

The eighth, and last, paper dealing with the "Constitution of Titanium Alloys" was by Dr. N. P. Allen, Mr. T. H. Schofield and Mrs. B. Mellish, of the Metallurgy Division, National Physical Laboratory, Teddington, Middlesex. The paper dealt with "The Constitution of the Titanium-Rich Alloys of Titanium, Iron and Oxygen," and the authors stated that their investigation had been made between 550 deg. and 1,100 deg. C., by microscopical and X-ray methods. Alloys containing up to 5 per cent. oxygen and 5 per cent. iron had been prepared from sponge titanium, pure iron and pure titanium dioxide, by arc-melting. The α and β phase fields were restricted at all temperatures, and the extent of the $(\alpha + \beta)$ field decreased with falling temperature between 1,100 deg. and 650 deg. C., owing to the progression of the $(\alpha + \beta + x)$ and the $(\alpha + \beta)$ fields, where x was a complex oxide of titanium and iron. At 550 deg. C., all the alloys investigated, except for a restricted α field, consisted of $(\alpha + FeTi)$.

DISCUSSION

Dr. N. P. Allen, who opened the discussion, stated that the constitutional work on the titanium alloys had reached an interesting stage, namely, details were now being filled in and differences between investigators were being discussed with a view to their settlement. A subsequent speaker, Mrs. M. K. McQuillan, emphasised that the titanium used in her researches on the titanium-chromium and titanium-gold systems was the purest available. Both chemical and spectrographic analyses had shown that the only appreciable impurity present was zirconium of the order of 0·5 atomic-per cent. The transformation range of the unalloyed material, which was the most useful criterion of its purity, was 872-880 deg. C. Dr. H. W. Worner, who spoke next, agreed that the transformation range was a criterion of purity. He added that it was advisable to report all analytical data available in papers of the type under discussion. The next speaker, Dr. H. Sutton, asked the authors whether they had seen any evidence of age-hardening phenomena in their systems. Other speakers raised the question of the possible effect of hydrogen on the structure of the alloys studied and discussed various points of detail.

CONCLUDING BUSINESS AND VISITS

At the end of the technical session, the President, Dr. S. F. Dorey, C.B.E., F.R.S., again took the chair, and votes of thanks to the Swiss Society of Machinery Constructors, the Swiss Association for the Testing of Materials, the Reception Committee in Switzerland, the Rector of the Federal Polytechnic for the accommodation afforded for the meeting, numerous Swiss establishments and companies for opening their works and laboratories to the visitors, and all others who had contributed in any way to the success of the meeting, terminated the proceedings.

On the following day, Saturday, September 11, the members travelled to Montreux, and Monday, September 13, was devoted to visits to works at Chippis, Cossonay and Geneva. On September 14, visits were made to works at Dornach, Gerlafingen and Choindez *en route* from Montreux to Bâle on the homeward journey to Britain.

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CONSTRUCTION OF GENERATING PLANT IN AUSTRALIA

New C. A. Parsons Factory Opened

As a result of the increasing demand for generating plant in Australia, C. A. Parsons and Company, Limited, Newcastle-upon-Tyne, decided to establish a works in that country. The site chosen was in South Australia at Whyalla and covers about 50 acres alongside the Port Augusta road. A company has been formed to operate the works and is known as C. A. Parsons of Australia, Limited.

The works were formally opened on September 27, by the Premier of South Australia, the Honourable Thomas Playford. The first section comprises a single bay of 400 ft. by 60 ft. with an annexe for the administration offices, drawing office, mess rooms and storerooms. It is equipped with an overhead crane and all the machine tools required for the manufacture of condensing and feed-heating plant, to which the output will at first be limited. This plant will be for use in conjunction with steam turbo-generators manufactured at Newcastle. The present structure has been designed to allow for expansion as this becomes necessary.

PROTECTION OF COASTAL LANDS AGAINST FLOODING AND EROSION*

DEFENCE WORKS AT SELSEY BILL

By J. Duvivier, B.SC., M.I.C.E.

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Under the terms of the Coast Protection Act, Chichester Rural District Council became the responsible authority for the maintenance and protection of some 16½ miles of coast between Chichester Harbour and Littlehampton. This includes Selsey, which has had the dubious distinction, since the turn of the century, of having lost more land for every yard of frontage than any other place in the British Isles. The problem, as elsewhere, arises largely as a result of the seaside "ribbon" development which has proceeded in the past with an entire disregard of the associated problems of erosion and inundation. Some of the frontagers have spent considerable sums of money on sea walls to protect their properties but isolated works of sea defence are rarely successful for long. To resist the sea successfully it is essential that works should form part of a properly co-ordinated scheme for the frontage as a whole.

A scheme promoted under the Coast Protection Act of 1949 is now under way for the protection of the eroding coast line over a length of 1½ miles east and west of Selsey Bill. The land mass at Selsey Bill is composed of beds of brick-earth, gravel and sand up to 30 ft. deep—known collectively as "drift"—overlying beds of grey, yellow and green sandy clay and shelly sands comprising the "Bracklesham Beds" which themselves overlie London clay at depths exceeding 350 ft. below the surface.

The open-textured friable silty clay of which brick-earth is composed and the gravel and sand beds which comprise the underlying "Raised Beach" offer little resistance to the waves, and the erosion of the shingle, gravel and sand beds exposed in the low cliffs which border the coast-line, and on the foreshore, provides most of the shingle and sand of which the Wittering, Selsey and Pagham beaches are composed. The supply, however, is insufficient to provide a natural protection to the coast without the help of artificial defences. The Bracklesham Beds consist of a dark grey-green compact medium to fine glauconitic sand containing patches and lenticles of clay and silt and are subject to the same process of denudation whenever the sea comes into contact with them, although the rate of wastage by wave action is slower. Their wastage when exposed is accelerated by boring mollusca by which they are freely attacked. The sea bed beyond low water is also subject to erosion and is progressively lowered as the land mass recedes.

* Conclusion of Paper read before Section G of the British Association at Oxford, on Monday, September 6, 1954. (Abridged.)

TOPOGRAPHY

The maintenance since 1923 of a lifeboat station on the east beach at Selsey, Fig. 8, has afforded a unique opportunity of observing the behaviour of the sea bed during the past 30 years. Periodic soundings and diving inspections have shown that the rate of erosion slows down as the depth increases, until the sea bed is eroded to a depth of about 2½ fathoms below low water, beyond which very little change seems to take place, the sea bed being covered with marine growth. This state of affairs is, in fact, what one would expect as the scouring action of storm waves progressively diminishes with the depth of water, and is borne out by a comparison of the off-shore contours shown on 1885 and 1946 editions of the Admiralty Chart which show an appreciable recession of the one-fathom contour, some recession of the two-fathom contour, and scarcely any change at three fathoms.

The sea bed is shallow to a distance of nearly four miles south of Selsey Bill, the area being encircled by a line of banks known by the general name of "The Owers." An inner shoal known as the "Mixon," is uncovered at low tide and is said to consist of limestone rock formed of the shells of certain Foraminifera. It is recorded (Heron-Allen) that rock was at one time extensively quarried from this reef and used for building purposes until the Admiralty put a stop to it on the entirely justifiable grounds that these rocks served as a defence against the rapid encroachment of the sea. The word "quarried" is perhaps an exaggeration, and the large-scale removal of stones from the Mixon must have been a costly undertaking at the best of times.

Fig. 8 East Selsey, Sussex, 1949. The broken line indicates position of coastline in 1922, since when the average rate of advance of the sea has been 25 ft. per year. This high rate is due to a natural high rate of erosion combined with an almost total absence of shingle replenishment.

WIND EFFECTS

The prevailing drift of shingle along the Sussex coast is from west to east, but an inspection of the coast from Chichester Harbour to Pagham showed that the drift divided at Selsey Bill. West of the Bill the drift is westward towards Wittering, whereas east of the Bill the drift is eastward towards Bognor. Selsey Bill therefore receives no fresh supplies of shingle by littoral drift to make up for periodical losses by scour. The reversal of drift to the west of Selsey Bill was investigated by preparing a wind diagram showing the prevalence and force of winds from various points of the compass over several years. Off-shore winds were disregarded, allowance was made for the sheltering effect of the Isle of Wight and a vector diagram was drawn to represent, in force and direction, all other winds of strong to gale force during the year. The direction of the resultant or average wind was found to be approximately S.S.W., as shown in Fig. 9. This is also roughly the orientation of the coast-line east of Selsey Bill, with the result that east of the Bill the shingle is moved rapidly in a north-easterly direction.

The speed at which this material is scoured and driven along the east beach is far in excess of the speed at which the beach is replenished by fresh material moving in from the west. Conditions east of Selsey Bill are therefore naturally conducive towards a rapid rate of erosion which, at the site of the lifeboat station, has averaged 25 ft. a year since the station was built in 1923, necessitating a successive lengthening of the approach gangway from the shore and considerable expenditure on underpinning the piled trestles which support the boathouse and slipway. Several houses have been destroyed by the sea and the two houses in the cluster at the end of the lifeboat gangway, which can be seen in Fig. 8, have been destroyed during the past two years.

It will be seen from Fig. 9 that west of Selsey Bill the average wind is from a quarter south of the perpendicular to the coastline. The waves produced by it are al o predominantly from a direction south of the perpendicular and the alongshore movement of shingle west of Selsey Bill is therefore, on balance, north-west towards Wittering. The inclination of the average or "resultant" wind to the general line of the foreshore in this case, however, is very much greater than in the case of the east beach and the rate of erosion west of Selsey Bill is therefore appreciably less than to the east of it and has averaged 4 to 5 ft. per annum since 1875.

PREVENTING SHINGLE MOVEMENT

In preparing a comprehensive scheme of defence for the Selsey peninsula it was therefore necessary to take into consideration the fact that as the drift divides at the Bill, once the erosion of the cliffs has been stopped by the construction of a sea wall or breastwork no fresh supplies of shingle will become available from the cliffs for the replenishment of the beaches on either side. It followed from this that in any new scheme of defence the utmost regard must be had to the importance of holding such shingle as then existed and preventing it from being swept away in a north-easterly or north-westerly direction, a state only to be achieved by means of groynes in conjunction with a sea wall.

A scheme was prepared in 1950 for the protec-

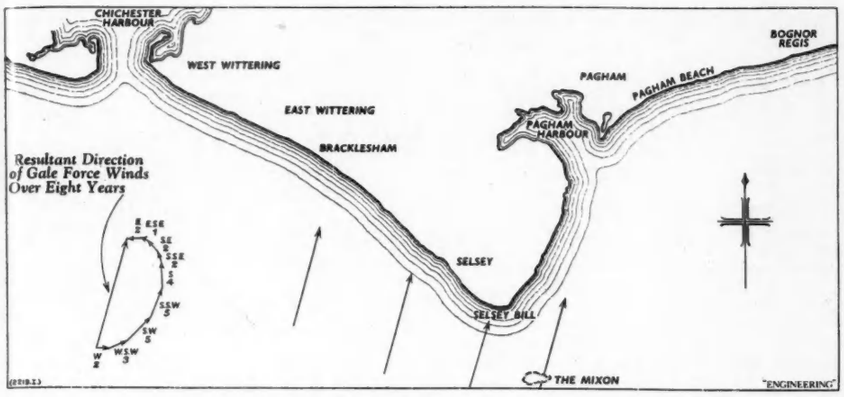

Fig. 9 The resultant wind direction at Selsey Bill accounts for the high rate of shingle movement on the east of the Bill towards Pagham and, on the west side, towards Wittering.

tion of the Selsey peninsula for a distance of a mile and a half each side of the Bill by means of sea walls, breastworks and groynes at an estimated cost of approximately half a million pounds. It was suggested in due course by the sponsoring Ministry that, in view of the restriction on capital expenditure and the shortage of steel which prevailed early in 1952, the cost of the scheme should be reduced to approximately a quarter of a million pounds spread over three or four years, and that the quantity of steel should be reduced from the 2,500 tons required to something less than 50 tons a year.

These somewhat drastic requirements were met in two ways, by reducing the length of coastline to be protected and by reducing the standard of protection. The Ministry's requirement in the matter of steel was met by redesigning the works to make use of alternative materials such as imported hardwoods, and by substituting mass concrete for reinforced concrete wherever possible. Here again it was realised that some sacrifice in the standard of protection was inevitable. A modified scheme was duly prepared and the Selsey Works Scheme was promoted under the terms of the Coast Protection Act (1949). The Ministry of Housing and Local Government in due course approved the execution of the first stage of the Works Scheme at an estimated cost of approximately £100,000.

During the time which elapsed between the preparation of a modified scheme and the completion of the formalities entailed in the promotion of a works scheme under the Coast Protection Act, steel had ceased to be one of the rare metals, and it was possible to design the works without having recourse to interlocking timber sheet piles and other expedients; the engineer's task was thereby greatly facilitated and the local authority's future liability for maintenance of the work was correspondingly reduced. The first contract comprised mainly the construction of works for the protection of residential property on the West Beach, but it also included a number of ancillary works at the point of the Bill and at parts of the East Beach.

ARTICULATED GROYNE

Fig. 10 shows all that remained in 1950 of the sea defences of Selsey Bill which had been carried out some years before the war by private owners, and by June, 1953, when the Selsey Coast Protection Scheme was commenced, further lengths of these old concrete defences had been destroyed. It was considered essential to the scheme of defence as a whole that every effort should be made to preserve what remained of Selsey Bill. The alternative policy of abandoning the tip of the peninsula and rounding off the Bill by constructing a new sea wall some distance landward of the cliff, although easier from the point of view of construction, would have weakened the coast line to the west and exposed a particularly vulnerable part of the East Beach to the scouring action of westerly gales from which it is sheltered by the point of the Bill. Provision was therefore made under the contract for stabilising the short remaining length of sea wall by encircling it with a continuous line of interlocking steel sheet piling driven to a substantial depth below beach level, and by constructing a heavy articulated concrete groyne of an experimental design just east of the Bill.

This groyne, which is shown in Fig. 11, consists of two parallel rows of heavy concrete blocks which are free to settle independently of one another, being held together below beach level by a flexible linkwork made up from lengths of old rails. The space between the two rows of blocks was filled with heavy rubble, while the western row was pinned to the underlying beach by pairs of steel rails driven through holes cast in the blocks. The rails were left projecting above the tops of the blocks to allow for the future heightening of the groyne if this is found to be necessary. It will be seen that an even beach has been held along both sides of this groyne, which has been free to adapt itself, without fracture of its component parts, to changes which have taken place.

Fig. 12 is a type section of the recently completed sea wall on the West Beach. This wall is founded throughout its length on silty sand and the load was spread over a wide area; the wall was secured against undermining by means of a wide sloping concrete apron, terminating in a row of interlocking steel sheet piles. The crest of the wall has been provided with a bull-nosed coping to protect the land behind against being scoured by spray thrown up by the impact of storm waves. With a view to economy the top of the wall was made 2 ft. lower than in the original design, and the coping is at a height of approximately 8 ft. 3 in. above M.H.W.S.T. This height, which is 2 to 3 ft. less than in the case of most sea walls on the South Coast, is sufficient provided the waves break on the beach and do not expend the bulk of their energy on the wall, but if the shingle beach falls below the level of the apron, as it may well do at times, water will be flung to a considerable height when a gale coincides with a period of high spring tides and a certain amount will be blown over the wall on to the land behind. This will not be a serious matter on the West Beach where the land behind is higher than on the east side.

Fig. 13 shows the eastern end of the recently completed West Beach wall and part of a permeable timber breastwork 150 ft. long which was designed to check the scour from spreading eastward and outflanking the new sea wall. The top of the planking is only 2 ft. above the level of high spring tides and the space between the planking and the cliff behind has been filled with rubble. The force of the waves is expended in running up the rubble slope and the water is free to drain back into the sea through open joints between the planks. This breastwork, which was built in conjunction with two short groynes, has served its purpose well so far and no extension beyond 150 ft. has been found necessary; it is appreciated, however, that a prolonged spell of westerly winds of strong to gale force may disturb the equilibrium of this beach and necessitate a further extension of the breastwork. Fig. 13 also shows one of the groynes which have been constructed along the West Beach wall with a view to distributing the somewhat meagre supply of shingle as evenly as possible along the frontage. The piles are steel rails bolted together in pairs, while the planking consists partly of Ekki and partly of greenheart, both imported hardwoods which are not affected by marine organisms such as the limnoria or the teredo to nearly the same extent as is the case with softwoods such as elm or Douglas fir.

STABILISING SANDY BEACHES

The protection of the East Beach at Selsey is a very much more difficult problem, partly because the rate of erosion is so high and partly because of the soft erodible nature of the subsoil which was shown by a geological survey carried out during 1953 to consist mainly of silty sand and silty clay down to a considerable depth, while the whole of the Fisherman's beach area was shown to consist of alluvium extending to such a depth that its base was not exposed by

Fig. 10 Private owners originally erected some isolated concrete defences which, however, lacked the continuity of a comprehensive scheme and, in consequence, failed.

Fig. 11 The articulated concrete groyne at Selsey Bill. The separate concrete blocks are joined by a flexible link-work which will allow a differential settlement to occur without damage to the groyne.

boreholes sunk to a depth of 30 ft. The geologist's report stated that this area coincided with some low-lying ground which must represent the silted-up outlet of a former stream, possibly dammed by a shingle spit. All the strata bored through were composed of soft or loose materials which are easily eroded and redistributed by wave action when the waves reach them. No tough resistant strata, such as one would have expected to find in view of the hard pile driving conditions experienced during the construction and maintenance of Selsey Lifeboat Station, were encountered within the range of materials bored through, with the exception of one or two isolated deposits which are exposed at low water of spring tides.

An unknown but undoubtedly substantial proportion of the fine, silty and sandy deposits will be carried out to sea in suspension and eventually deposited on the sea bed beyond the range of submarine wave action. The coarser parts, however, may lie within the range of granular material that is normally encountered on beaches between the levels of low and high water, in which case they may be depended upon in due course to augment the supply of littoral drift. The present slope of the East Beach varies between 1 in 4½ and 1 in 10, and these slopes are far too steep to allow fine or even coarse sand to remain within the range of the tide for any length of time unless there is enough shingle mixed with it to give it the characteristic properties and greater stability of a gravel beach.

The reaction of a beach to the construction of a scheme of sea defence comprising a sea wall or breastwork and groynes depends to a large extent upon the nature of the material of which the foreshore is composed, that is to say, the undisturbed strata under the loose shifting cover of gravel or sand. If it is soft clay it can be very troublesome. Thus, at Hayling Island, out of a total length of 5,000 ft. of sea wall that has been built during the past six years 2,160 ft., or 43 per cent., has had to be protected by a low level apron due to the rapid erosion of the underlying soft clay. The rest is stable and seems likely to remain so as there is no clay near the surface. Similar conditions at Fleetwood, Lancashire, have necessitated the provision of a second and, in places, a third stage apron due to the disintegration of the clay.

At both these places the trouble was due to the fact that the sea walls were built on clay which outcropped on the foreshore within the full range of the tide. At neither place was there enough shingle or gravel on the foreshore to cover the clay during storms, neither was it found possible to gather and retain enough shingle or gravel by means of groynes to serve as a protective covering to the clay. At Selsey, the clay varies both in level and in character, and the protection of the East Beach frontage and the promotion of safe and stable conditions is a complex problem. The scheme which has been devised for the protection of this side of the peninsula comprises in the first instance the construction of a steel sheet-piled breastwork, just over 4,000 ft. long and a large number of steel groynes.

The object in using steel piling for the first stage in the construction of the sea wall and the groynes has been to provide full protection to the most vulnerable and unprotected parts of the coast line in the shortest time. Steel sheet piling fulfils this requirement and it is fortunate that as much of this material can now be obtained as is required. Apart from the initial advantage of speed of construction, steel sheet piling has the further advantage of being readily adaptable to changed conditions and can be re-driven to a greater depth or extracted and re-used.

The Selsey scheme should be well advanced towards completion by the end of 1955, but some years may elapse before the coast line settles down to the new regime. The groynes and breastwork will require to be carefully nursed while the settling-down process takes place, and the design has therefore been phased to allow for the changes that are likely to take place in the level and character of the foreshore.

ECONOMIC AND LEGAL ASPECTS

Until the passing of the Coast Protection Act (1949) neither the central Government nor the local authorities were empowered to spend public funds in protecting private property against damage or destruction by the sea. Until then it had been accepted as just and fair that each man should be responsible for protecting his own property. By the same token the State imposed no obligation upon an owner to protect his property against erosion, and the owner, whether a private person, a company, or a local authority, was at liberty to allow his land to fall into the sea if he considered that the financial outlay entailed in constructing sea defence works would be more than the property was worth or more than he could afford to pay.

Prior to 1949 works of sea defence ranked for grant aid from the Treasury only if (*a*) a main highway was threatened, in which case the Minister of Transport was empowered to contribute towards the cost of approved remedial works, and (*b*) if a catchment area abutted on the sea or on an estuary, in which case the catchment board was empowered to construct such works in the sea or estuary as might be necessary to secure an adequate outfall for the main river, and the Minister of Agriculture and Fisheries was empowered to make grants towards the expenditure incurred, amounting, in exceptional cases, to as much as 80 per cent. of the cost of the works.

Under the new Coast Protection Act (1949) the local authorities, i.e., the Borough Councils, the Urban District Councils and the Rural District Councils whose boundaries terminated at the coast, were given a number of new powers which they were encouraged to use in the promotion of essential schemes for the protection of the coast-line in their area. These powers do not extend to the areas of low-lying coastal land which are administered by the River Boards.

Quoting somewhat freely from the explanatory memorandum attached to the Act the new powers conferred upon Local Authorities are briefly as follows: (*a*) to carry out work for the protection of any land in their area, not merely publicly owned land; (*b*) to carry out these works either on land to be acquired by them for the purpose or privately; (*c*) to levy "coast protection charges" upon owners of land which will be benefited by the works; (*d*) to acquire, compulsorily if need be, land required for the works, or in certain cases, to acquire land which will be protected when the land has not been put to good use; (*e*) to enforce the maintenance by owners of privately owned works or the carrying out of customary coast protection duties under local Acts; (*f*) to control the carrying out of coast protection works by persons not acting under statute; (*g*) to be informed of works to be carried out by certain authorities and if necessary to object to them; (*h*) to prevent the uncontrolled removal of material from the foreshore.

It is intended that the cost of work carried out under any approved scheme shall be met (1) by contributions from private owners or commercial interests which benefit from the works whether they be frontagers or owners of back land; (2) by contributions from other authorities such as highway or drainage or railway authorities if they derive benefit from the works; (3) by contributions from the County Council; (4) by grants from the National Exchequer through the Ministry of Housing; (5) the balance of cost, if any, is paid for by the Coast Protection Authority out of the district rates.

Contributions from private or commercial interests under (1) above are levied on the advice of the District Valuer, and may be assessed at the value of the interest after the works have been completed minus the value of the interest if the works had not been undertaken; in other words, the increase in the value of the property as a result of the works.

Owners of property who feel aggrieved by the assessment of their liability (a fairly common state of affairs in works schemes which have been promoted to date) can appeal and the Ministry undertake to give them an opportunity of stating their case to an inspector. After hearing the facts of the case the inspector can confirm, reduce or cancel the charge as the Minister may think fit. The charge is not payable until the dispute is settled. Coast protection charges may be paid by instalments.

Contributions from the County under (3) above may be up to any amount that may be agreed between the County Council and the Coast Protection Authority, but the County are under no obligation to make a contribution which is in excess of the amount of the Exchequer grant, nor can they be compelled to make grants towards the cost of coast defence in the County which will exceed the product of a 1*d.* rate levied over the whole of the County.

Government grants, in the words of the Memorandum, "are not to be decided upon a rigid formula but according to the circumstances of the particular case." The main consideration will be the burden which the cost of the work will throw on the local rates. The Exchequer grant is not usually announced until the other contributions have been settled.

A large number of essential coast protection schemes have been carried out during the four and a half years which have elapsed since the passing of the Coast Protection Act. Few, if any, however, of these could have been under-

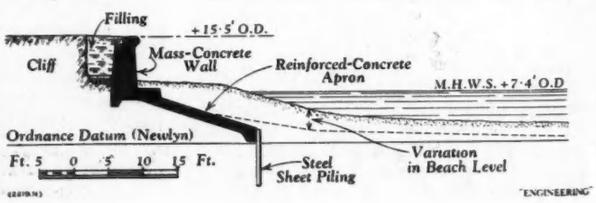

Fig. 12 The new West Beach sea wall for the Selsey sea-defence scheme. The wall is secured against undermining by the apron and sheet-pile skirting.

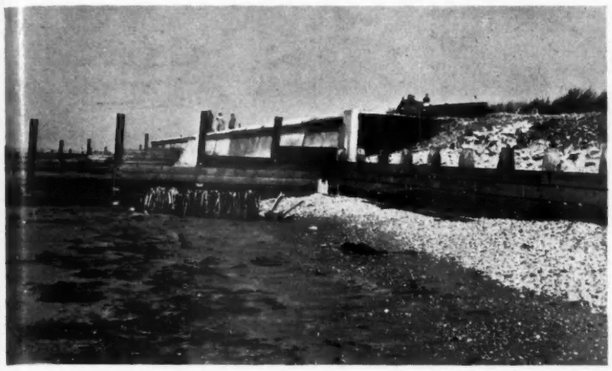

Fig. 13 The new sea wall, groynes and permeable timber breastwork along Selsey West Beach. The groynes have been designed to retain and distribute the shingle along the front.

taken but for the powers which were conferred upon the local authorities concerned to organise co-ordinated schemes for the protection of the areas as a whole, and to ensure that each property owner who benefits pays a fair and reasonable contribution towards the cost of the works.

In only one case, however, with which the author has been associated, has it been possible to proceed with the scheme by agreement; in every other case it has been necessary to proceed by the exercise of compulsory powers under what is known as "works scheme procedure." Almost invariably objections have been lodged by persons whose properties have been included in "the contributory area," the objections usually being that properties so included should not have been included and vice versa.

Few of these objections have been seriously sustained at the inquiries and the author is convinced that if some arrangement could be made whereby contributors towards these schemes could be given some indication in advance of the amounts they will be called upon to pay towards the cost of the protective works comparatively few objections would be made. As things are, most of the persons concerned come to the inquiries in complete ignorance as to whether they will be called upon in due course to pay £20, £200 or £2,000 towards the cost of the works, and this is a state of affairs which could be easily rectified if the Coast Protection Authorities acted under the powers conferred upon them by Section 7(4)(*a*) of the Act which enables them to specify the charge to be paid by each person when the works scheme is promoted.

With regard to coast protection in the areas administered by the River Boards it is unfortunate that in the past many of these River Boards have been unable, due to a shortage of funds, to do all that is necessary for the protection not only of the main outlet of the rivers in their areas which is their main function, but also for the residential population in these areas. There is no doubt that many built-up areas in low-lying coastal lands should never have been allowed to develop. The fact remains that they exist, like the ribbon development that was allowed to spring up along the new by-pass roads built between the wars, and it is necessary to make the best of a bad job. Presumably, they cannot be evacuated and it seems that the only alternative will be for the central Government to provide larger grants to the River Boards to enable them to discharge their responsibilities to all who rely on them for protection.

Correspondence on this British Association paper will be considered for publication in "Engineering."

THE MECHANISM OF A SIMPLE DRAWING OPERATION*

A STUDY OF STRETCH-FORMING

By Professor H. W. Swift, M.A., D.SC. (ENG.), M.I.MECH.E.

In this paper an attempt is made to review experimental and analytical investigations which have been made into the mechanism of deep drawing. The primary objectives of such studies have been to make it possible to predict (*a*) the press load required to perform a particular drawing operation, (*b*) the stresses and strains induced in the sheet metal during this operation, and (*c*) the probability that metal of known mechanical properties will draw successfully. A secondary, though industrially no less important, objective has been the development of a reliable procedure for testing the drawability of sheet metal.

Although the several functional factors which control the process of deep drawing are easy to enumerate, their effects are not easy to examine by the usually convenient device of separating the variables. It is still more difficult to study their mutual reactions when in joint operation. For this reason the only deep-drawing operation which has yet received any systematic experimental or analytical study is the production of a cylindrical cup from a flat circular blank in one or two stages.

The scope of the present review is therefore necessarily limited to work on this relatively simple operation, and since most of the recent and systematic experimental work in this field has been carried out in the engineering laboratories of the University of Sheffield, it is natural that the discussion should be based on the experimental techniques and equipment developed in these laboratories and on the results obtained there. It should be pointed out that this work has been carried out for a number of years under the ægis of a succession of composite committees supported by industrial research associations, and that it is now under the ægis of the Sheet Metal Working Committee of the British Iron and Steel Research Association.

* Paper read before Section G of the British Association, at Oxford, on Monday, September 6, 1954. (Abridged.)

EXPERIMENTAL EQUIPMENT

Most of the experimental results recorded in this paper were obtained in a specially designed crank press[1] having a nominal capacity of 50 tons, and an actual capacity of 20 tons over a range of speeds from 5½ to 60 strokes per minute and of strokes from 3 in. to 10 in. The drawing tool used in association with this press is mounted on a 24-in. diameter diaphragm for autographic recording and can embody a special punch fitted with strain gauges to distinguish the punch-head load from that transmitted by traction through the shell walls.

The procedure followed in the preparation and drawing of blanks has been described elsewhere.[2] For present purposes it is sufficient to record (*a*) that the standard lubricant was a mixture of graphite and tallow applied to both sides of the blank and (*b*) that thickness strains were measured directly in a special fixture by means of a dial-gauge micrometer. Strains developed at intermediate stages of the drawing process were measured on "partial pressings" obtained by stopping the press at part-stroke.

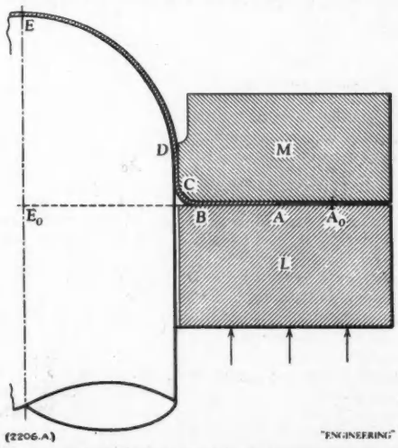

Fig. 1 Hemispherical-ended shell at an intermediate stage during drawing when the punch load is about its greatest.

The conditions covered in the experimental investigations are conveniently enumerated in reference to Fig. 1 which shows diagrammatically a hemispherical-ended shell at an intermediate stage of the drawing process, approximately at the point of maximum punch load. The drawing conditions depend primarily of course on the ratio (known as the "drawing ratio") of the initial blank diameter to the punch diameter, and on the blank thickness. Other significant factors are (*a*) the conditions of blank-holding, which may be affected either by a constant clearance or by a constant pressure between the parts marked L, M; (*b*) the die profile radius between the shoulder B and the throat C of the die; (*c*) the radial clearance between punch and die in the region CD; and (*d*) the form of the punch-head profile DE. The type and distribution of lubricant and the speed of drawing are also potentially significant conditions.

The conditions imposed on the sheet metal by the drawing process are essentially those of impressed strain, and the stresses to which the material becomes subject and the load transmitted by the punch are those induced by the system of strains having regard to the plastic

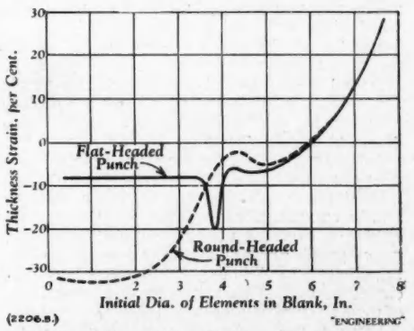

Fig. 2 Distribution of thickness strain from the centre to the rim for cups drawn over flat-headed and round-headed punches.

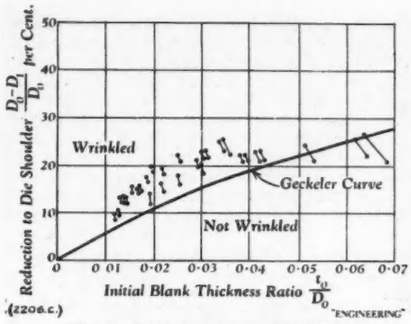

Fig. 3 Limits of flange wrinkling.

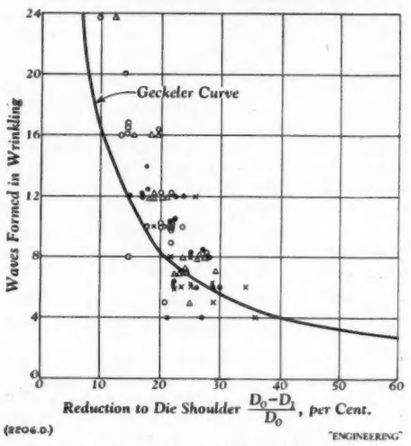

Fig. 4 Number of waves formed in wrinkling.

Figs. 3 and 4 Geckeler's analysis is shown here to be of the correct form but quantitatively on the low side.

properties of the material and to the conditions at free surfaces and boundaries. The systems of straining are basically different in the outer region of the blank which is initially held between the die and blank holder and in the central region over the punch head.

ANALYSIS OF PLASTIC DEFORMATION

Material from the outer region, as it is drawn radially inwards towards the throat of the die, is subjected to a continually increasing compressive strain in the hoop direction combined with an extensile strain in the radial direction, and these jointly induce strains in the third principal direction which generally cause a continuous thickening of the sheet material as it moves inwards. When it reaches the shoulder of the die it is plastically bent and subsequently unbent over the die profile BC (Fig. 1) while under substantial tensile stress in the "radial" direction, and this plastic bending under tension gives rise to a notable and basically predictable thinning of the metal.[3] This thinning is of course superimposed and modifies the thickening which has occurred during radial drawing. When the outer region metal has passed the die throat C to form part of the cylindrical wall of the shell it may be subject to further extensile strain in the axial direction, but this is generally insignificant and straining of this metal then ceases at or just beyond C.

In contrast to this, the metal in the inner zone over the punch head is at no stage subject to inward radial drawing, but is under biaxially tensile conditions throughout the draw, which stretch it over the punch head and round the punch profile and so necessarily induce a general thinning. This thinning is accentuated on the curved part of the punch profile due to the effect of plastic bending under tension.

Between the inner and outer regions of the blank there is a ring of metal which escapes bending over the die or the punch profile and is drawn very slightly if at all. This metal, in effect, merely transmits the drawing force between the two regions and it is under relatively simple tensile conditions throughout the draw.

This descriptive account of the plastic history of the drawing process will help to explain the general form of two characteristic types of diagram which are easily obtained experimentally and are of great practical significance: the so-called "autographic diagram" in which the punch load is plotted in terms of the punch movement, and the curve showing the distribution of metal thickness at various regions from the centre to the rim as shown in Fig. 2. In this diagram the two curves compare values for flat- and round-headed punches under otherwise similar conditions.

BLANK HOLDING

Unless the metal blanks is comparatively thick and the drawing ratio small, blank-holding is necessary to prevent the development of radial wrinkles in the flange at an early stage of the draw. Such wrinkles, once developed, are difficult to iron out and if at all severe may well induce a fatally large punch load when they reach the throat of the die. The conditions under which wrinkling is liable to occur have been studied theoretically by Geckeler[4], who treated the flange as a strut with one longitudinal (actually circumferential) edge under constraint and obtained relations showing for conditions of no blank-holding (*a*) the hoop compressive stress which will initiate wrinkling and (*b*) the number of wrinkles which will form round the flange. Experimental investigations at Sheffield,[5] the results of which are plotted in Figs. 3 and 4, have shown that Geckeler's relations both show satisfactory trends but are quantitatively unreliable.

In practice, the number of wrinkles is of purely academic interest and very few drawing operations could be successfully performed without blank-holding, so a more important question concerns the severity of holding necessary. Two methods of holding are adopted; in one a positive clearance is provided (perhaps 6 per cent. of the blank thickness) between the faces of die and blank-holder, while in the other a prescribed blank-holding force is impressed between these faces by some more or less elastic medium. In effect, the former method merges into the latter when, as is usual, the blank thickens to fill the clearance and the elasticity of the tools provides a graded blank-holding force. Assuming that the tendency for wrinkling is suppressed, it is possible to estimate theoretically the effect of a given blank-holding force on the punch load and thickness strains, and in those cases in which the not inconsiderable computations have been made they have been found to agree quite well with experiment. More systematic experiment has shown[6] that provided it exceeds a necessary minimum, the blank-holding force has practically no effect on the maximum punch load over a range of at least 4 to 1, and its effect on the thickness distribution is quite small in the critical regions. Its value is therefore by no means critical, either in experiment or in practice, and mean pressures over the flange of about 400 lb. per sq. in. for steel and 250 lb. per sq. in. for aluminium have been found satisfactory on the scale of the Sheffield experiments.

DRAWING LOADS AND STRAINS

For reasons already explained it is not practicable to apply to the whole of a circular blank a common analytical treatment of the drawing process. The outer and inner regions require separate examination. Since the boundary and impressed conditions at all stages of drawing are more clearly defined for the outer drawing region, and in effect the conditions in the inner stretch-forming region, over the punch head, are prescribed by those in the outer region, an understanding of the stresses and strains in the outer region is necessary before those involved in stretch-forming over the punch head can be profitably considered.

Several attempts have been made during the past 25 years to predict the stresses, strains and

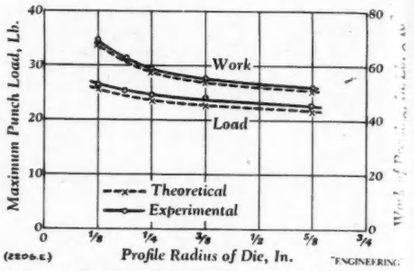

Fig. 5 Effect of die profile on drawing load and work.

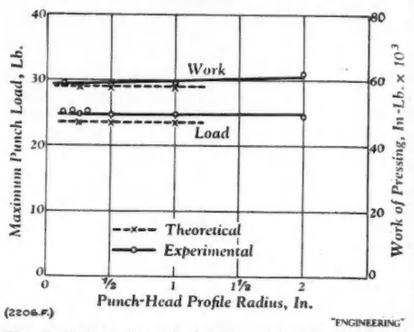

Fig. 6 Effect of punch profile on drawing load and work.

forces involved in radial drawing, but partly because of the simplifying assumptions made to reduce computation and partly through the neglect of plastic bending strains, it was only in 1951 that a treatment[3] was elaborated which could face comparison with experimental results obtained from a practical drawing operation. Even this treatment is based on a number of physical assumptions which are known not to be strictly valid, on certain approximations in analytical manipulation and on plastic overstrain of the principle of superposition. But its results have proved to be sufficiently satisfactory over a range of materials and conditions to suggest that the several assumptions are reasonable and that no significant factors have been overlooked.

In the region of pure radial drawing it is assumed that the material yields according to the Levy-Mises hypothesis, that it strains isovolumetrically according to the Levy-Lode relationship and that its strain-hardening characteristic can be expressed in the form of the Ludwik power law without regard for speed of

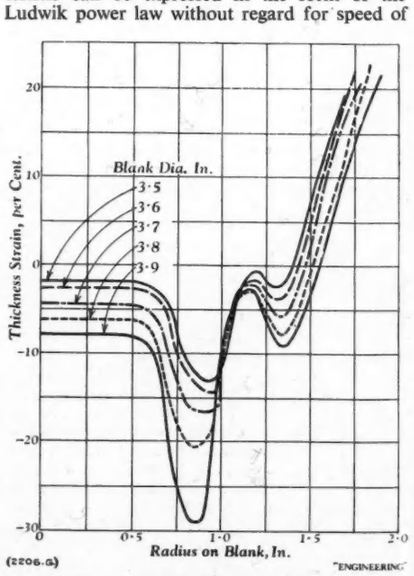

Fig. 7 Effect of blank diameter and radius on thickness strain.

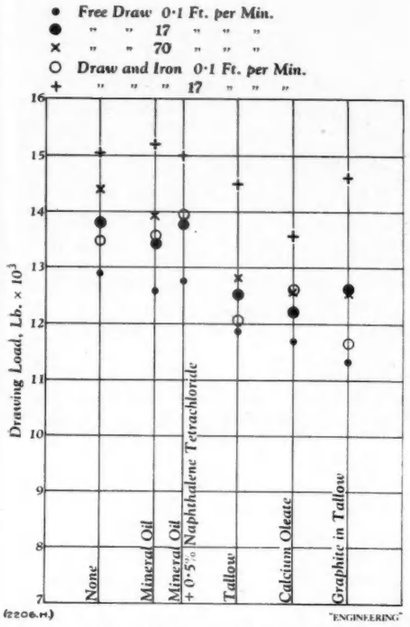

Fig. 8 Effect of lubricant and speed on drawing load.

straining. It is assumed further that the blank-holding force is at all stages transmitted across the outer rim, and at the same time that the flange thickness is sensibly uniform at any moment. In the region of plastic bending and unbending over the die profile it is assumed that the work-hardening rate is uniform, that the Bauschinger effect can be neglected and that unbending stresses are insensitive to differences of strain history. Conditions of plane stress are assumed throughout and the stresses due to drawing, bending and die-profile friction are superposed.

STRAIN CALCULATION

Computations based on the theoretical treatment have been made over a fairly wide range of practical drawing conditions which could be reproduced experimentally in the laboratory. In all cases a sheet thickness of 0·039 in. has been assumed and in most cases a punch diameter of 4 in. Computations have covered die-profile radii from $\frac{1}{4}$ in. to $\frac{8}{8}$ in., blank diameters from 6 in. to 8 in., four different materials (mild steel, soft aluminium, half-hard brass and half-hard copper), punch-profile radii from $\frac{1}{4}$ in. to 1 in., blank-holding forces of 15,500 lb. and 33,000 lb., and frictional conditions approximating to graphite lubrication ($\mu = 0{\cdot}06$) and to no lubrication ($\mu = 0{\cdot}128$). One calculation has been made for a 2-in. diameter punch. In all these cases experimental measurements have also been made of punch loads and thickness strains and two representative comparisons between theory and experiment are shown in Fig. 6.

The results plotted in Figs. 5 and 6 show that the analytical method is capable of predicting the effect of the die and punch radii on the maximum drawing load and on the punch-work absorbed in the drawing operation. The punch load-travel diagram can be predicted in fair detail for widely different punch profiles. The different strain-hardening characteristics of the four materials used can be embodied in calculations of thickness changes in the shell walls,[7] and these characteristics lead to punch load-travel diagrams satisfactory in scale and form.

Among the numerous comparisons made between theory and experiment the only ones which have proved not wholly satisfactory have been those of thickness changes in the walls of mild-steel shells, and the punch load-travel diagram for a small-sized cup involving proportionately large bending effects.

The labour, however, of computing drawing loads and strains is so considerable that the

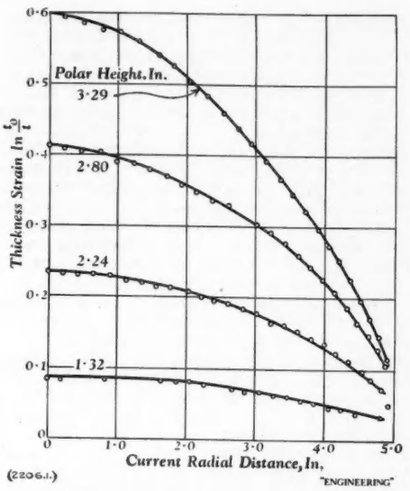

Fig. 9 Distribution of thickness strains for mild steel under hydrostatic bulge.

systematic effects of various factors are generally easier to investigate experimentally, even when they are concerned with the radial-drawing as distinct from the stretch-forming region of the blank. In the light of a number of experimental investigations based on 2-in. and 4-in. diameter punches, the effects of the geometrical conditions of drawing can be summarised quite shortly. With greater blank diameters the punch load increases in an approximately linear manner, while the walls and base of the drawn shell are progressively thinner. This is clearly shown for relatively small, thick blanks by the results plotted in Fig. 7.* Thicker blanks naturally involve greater drawing loads and severer bending strains over die and punch profiles, but blank-holding conditions are easier and it is found that the metal is relatively thicker in the shell walls, though relatively thinner elsewhere. A sharp die-profile radius tends to increase the frictional component of the drawing load and also leads to greater thinning due to bending and unbending. But provided that this profile radius is not less than about ten times the metal thickness, these effects are quite small and innocuous. The punch-profile radius has little or no effect on the value of the maximum punch load, but a generous curvature delays the point at which this maximum occurs. It has little effect on the thickness of the shell walls, since this is largely determined by the drawing load, but it is of course the primary factor determining changes of thickness in and around the base of the shell.

The effects of lubrication and drawing speed should logically be considered together, because the efficacy of a lubricant under the high transient pressures of a drawing operation depends more on its ability to resist expulsion than on its intrinsic anti-frictional qualities, and a fast drawing operation gives less time for expulsion. It is not therefore surprising that a large number of comparative tests over a period of years have shown that the best lubricants, as assessed by their ability to reduce the drawing load, are characterised by a solid constituent. At Sheffield, where good and consistent lubrication has been required in general investigations, a satisfactory standard has been found in a mixture by weight of one part of colloidal graphite with three parts of tallow. Fig. 8 gives some idea of the joint effects of speed and lubrication under free drawing conditions and under drawing conditions involving "ironing" of the metal through a restricted clearance between punch and die. This figure demonstrates the efficacy of solid lubricants and shows that this is more marked at slow drawing speeds. It also shows that with a given lubricant higher drawing speeds tend to increase the drawing load.

* Data for these tests: mild steel blanks, $\frac{1}{8}$ in. thick; punch, diameter 2 in.; die-profile radius, $\frac{3}{8}$ in.; drawing speed, 10 ft. per min. Graphite and tallow lubrication.

DRAWING OVER THE PUNCH

Discussion hitherto has been confined to the radial-drawing region. The conditions in this region control directly the drawing force (except in the earliest stage when the punch profile may introduce toggle action) and strains in the radial-drawing region, and since the drawing force has to be transmitted by the walls at D, Fig. 1, it determines the boundary conditions for the stretch-forming region over the punch head. In conjunction with the punch profile and frictional conditions it therefore determines the strains over the punch head.

The conditions over the punch head are important. In the first place intrinsic differences of thickness in this region of the drawn shell may well be of more practical concern than those in the shell walls, because they cannot be controlled by the imposition of ironing. But, still more important, these conditions in most cases determine whether or not the shell is sufficiently strong at all points and stages to sustain the drawing force demanded by the radial-drawing zone, and therefore whether the drawing operation is possible.

Conditions over the punch head, as indeed local conditions at all zones and stages, are conveniently appreciated through changes in thickness distribution, and preliminary discussion may well be based on a system of curves of the type shown in Fig. 19*c* of Reference 2. In this figure the drawing region comprises initial diameters above 4½ in., the stretch-forming region diameters below about 4 in., while between 4 in. and 4½ in. is the zone which escapes bending over either die or punch profile. Mild-steel blanks 0·039 in. thick and 8 in. in diameter were used. The die-profile radius was $\frac{1}{4}$ in. Curves similar in type, for a fixed tool geometry but various blank diameters, are shown in Fig. 7.

Thickness changes in the drawing zone can be predicted by theory. The zone of local thinning corresponds to metal which has been drawn (slightly), bent and unbent under high radial tension, while metal in the adjacent intermediate zone has been under relatively simple tensile conditions and has not been subject to the thinning which accompanies plastic bending under tension. The greater thinning in the neck with sharper punch-head profiles is a secondary effect, due to the greater drawing tension at the early stage when this zone of metal is bent over the die; with more rounded punch heads the drawing tension rises more slowly.

Thickness changes over the heads of the various punches are easily explained in general terms. With a flat head and sharp profile radius, the sheet metal over the flat head is effectively protected from the drawing tension by the profile radius and the friction associated with it. But the metal over the profile radius is thinned by the plastic bending to which it is subject during the stretch-forming process. This local thinning gives rise to a second neck which is almost co-extensive with the zone of plastic bending over the punch profile. The severity of this bending, and therefore of the local necking, increases with the sharpness of the profile.

Conditions over a round-headed punch are rather different. In this case the effect of plastic bending is comparatively small, but at the same time the metal on the punch head is less effectively protected from the drawing tension, so that the straining conditions are intrinsically those of stretch-forming. The thinning in the second neck is severe with sharp-profiled punches owing to local bending, and it is severe with the round-headed punches due to (more general) stretch-forming. It is least severe for an intermediate punch profile, on which the bending is insufficient to cause severe thinning itself but sufficient to protect the metal over the punch head from the full effects of stretch-forming.

The greater thinning with larger blanks, in both drawing and stretching regions, as revealed in Fig. 7, is due of course to the greater radial

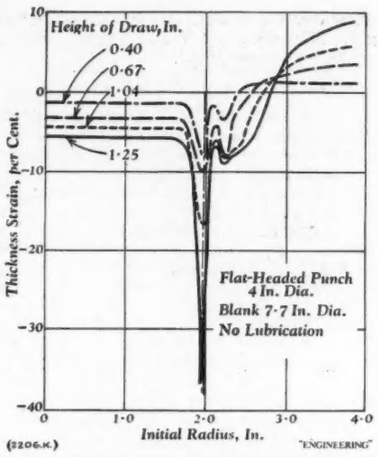

Fig. 10 Development of thickness strains from a blank of critical size drawn over an unlubricated flat-headed punch.

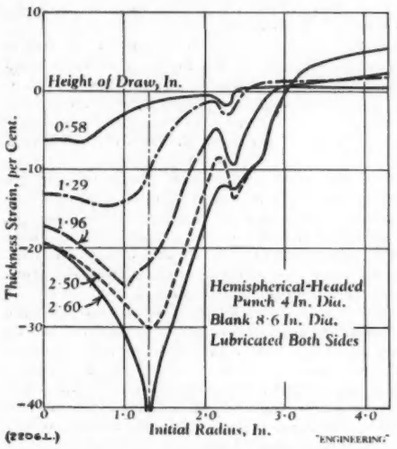

Fig. 11 Development of thickness strains from an oversize blank drawn over a lubricated hemispherical-headed punch.

tensile stresses under which plastic bending occurs over die and punch profiles. It is to be noted that the thinning is substantially uniform over the flat head of the punch because the conditions here are essentially those of uniform biaxial tension.

Any full appreciation of conditions over the punch head and their effect on drawability must be based on an understanding of stretch-forming. This introduces analytical problems quite as intractable as those of radial drawing and is unlikely to be workably understood for some time. In the meantime something can be gained from a descriptive appreciation of the effect of various conditions in the drawing process on the development and distribution of strains, the limits of drawability and the incidence of failure. At the same time, something can be done to meet the legitimate demand of industry for a reliable test for drawability, if only by a direct empirical investigation of the most promising simulative forms of test.

STRETCH-FORMING

A complete study of the part played by stretch-forming in a deep-drawing operation must include: (i) examination of the development of stress and strain in sheet metal formed over a punch head of given profile under specified frictional conditions, with varying boundary conditions imposed by the radial drawing regime, the metal having known strain-hardening characteristics; and (ii) investigation of the conditions under which this strain development becomes unstable, so that local rupture occurs. This phenomenon is of course analogous to "necking" under simple tension, but it involves not only study of the critical degree of thinning under plane stress but also location of the particular zone in which this will occur. It cannot, therefore, be fully treated until the study of (i), above, is well advanced.

The conditions under which plastic strain becomes unstable under a pair of principal stresses of given proportions have been examined theoretically[8] and it is known that the critical degree of thinning with strain-hardening material is considerably greater under biaxial stress than under simple tension. The assumed stress-strain relation was $q = c\ (a + \psi)^n$.

This theory has been applied to conditions in the hydrostatic bulge—a circular disc clamped round the periphery and subjected to fluid pressure on one side—which is a true stretch-forming process, though simplified by the absence of friction and made somewhat unrealistic by lack of definition of the final profile. In this case theory predicts that critical thinning and consequent rupture will occur at the central pole of the bulge and that the residual thickness ratio at the " neck " for different materials will be in accordance with Fig. 7 of Reference 8. Experimental measurements on bulges 10 in. in diameter formed from 20-s.w.g. metal confirm that necking occurs near the pole and show residual thickness ratios ranging from 0·53 with aluminium, copper and brass in the soft condition, through 0·58 with mild steel, to 0·69 with half-hard aluminium. These figures correspond to reasonable strain-hardening constants in Fig. 7 of Reference 8.

Unfortunately, the hydrostatic bulge is quite unrepresentative of stretch-forming over a punch, even with clamped edges. Fig. 9 shows thickness distribution curves at successive stages of stretching for mild steel under hydrostatic bulge.

When no lubricant was applied,[9] further marked differences appeared which suggest that stretch-forming is very sensitive to operating conditions and show that lubrication is a dominant factor and not merely a corrective in this operation. Without lubrication rupture occurs with a punch penetration of 3·05 in. and at a radial distance 3·4 in. from the centre, while under efficient lubrication the critical punch penetration is 3·7 in. and the neck is only 2·2 in. from the centre. Closer examination of the results shows that without lubrication the region of maximum thinning at any stage coincides with the ring at which the sheet is just making contact with the punch head, while with good lubrication the neck, which is less marked, always lies on the rounded profile closer to the pole. An analytical procedure has been suggested[10] for the study of stretch-forming over a cylindrical punch, but no real progress has yet been made.

PUNCH-HEAD STRAINS

In normal deep-drawing the strain state over the punch head are not so simple as in stretch-forming with clamped boundaries. For the boundary conditions in that case are determined by the drawing force, which varies from stage to stage of the drawing process and depends on several factors, including notably lubrication of the die profile. It so happens that lubrication on the die profile and on the punch head can be controlled separately—at least under experimental conditions—by different treatment of the two sides of the blank, so the important effects of friction at least can be studied separately in relation to drawing proper and stretch-forming over the punch.

A series of tests have been made to determine the limiting conditions of successful drawing for killed mild steel with different modes of lubrication over two punches, each 4 in. in diameter, one with a hemispherical head and the other with a flat head and a profile radius of $\frac{1}{4}$ in. The tests were made in the laboratory hydraulic press at a mean drawing speed of 14 ft. per minute. The results are shown in Table I. It is notable that although lubrication on the die

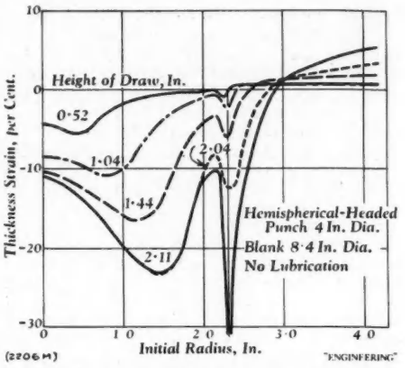

Fig. 12 Development of thickness strains from oversize blank drawn over an unlubricated punch. The effect of lubrication can be seen by comparing this graph with Fig. 11.

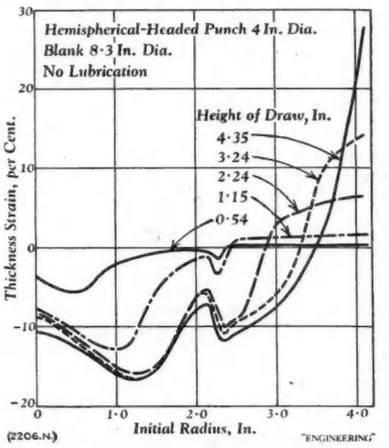

Fig. 13 Development of thickness strains during drawing of the largest-size blank that can be successfully drawn under the specified conditions.

side of the blank improves the drawability, lubrication of the punch side tends to reduce it. It is also notable that although as a rule the critical neck (at which fracture occurs) is that which forms on the punch-head profile; in the case of a round-headed punch if the punch side is left unlubricated it is the neck on the cylindrical shell wall which proves critical. With the flat-headed punch the maximum drawing loads as well as the maximum drawing diameters are consistently less than with the round-headed punch. This is, of course, due to the different conditions of straining over the punch head, and particularly to the mode of development of the profile neck.

The development of thickness strains in the critical region is shown by the representative curves plotted in Figs. 10 to 13, from measurements on some of the shells included in Table I. Fig. 10 shows the strain development in the critical size of blank for the flat-headed punch without lubrication. This development is clearly distinguished in the various zones and needs little comment. The outer region has thickened

TABLE I.—*Effects of Lubrication on Drawability*

Punch	Lubrication		Limiting Values	
	Punch	Die	Blank Dia.	Load, Tons
Round	No	No	8·3	13·7
Round	Yes	No	8·1	12·7
Round	No	Yes	8·9	14·5
Round	Yes	Yes	8·5	13·3
Flat	No	No	7·6	13·2
Flat	Yes	No	7·6	12·0
Flat	No	Yes	8·1	13·3
Flat	Yes	Yes	7·9	12·9

relatively little because fracture has occurred at a comparatively early stage of drawing.

Figs. 11 and 12 compare strain development in oversized blanks when drawn over the round-headed punch with and without lubrication. It is clear that lubrication results in greater general strain over the punch head, but it is remarkable that the local thinning in this region can reach 30 per cent. before conditions become unstable, whereas fracture supervenes if the thinning in the wall neck reaches about 13 per cent. In this connection a comparison between Figs. 12 and 13 is of interest. Fig. 13 refers to the largest size of blank capable of successful drawing under the specified conditions; Fig. 12 to the smallest oversized blank under the same conditions. In Fig. 13 the profile neck is more severe (17 per cent.) than the wall neck (12 per cent.). Yet Fig. 12 shows that failure is imminent in the wall and not on the profile. This apparent anomaly is no doubt due to a difference in the types of biaxial stress; the stress ratio $\frac{p_2}{p_1}$ will be about 0·5 in the wall and may well approach unity over the punch head.

TESTS FOR DRAWABILITY

A general consideration of the mechanism of deep-drawing suggests that three of the numerous forms of test which have been proposed to compare drawing properties are worthy of serious consideration. The general elongation which a metal can sustain before necking occurs in the ordinary tensile test is clearly a measure of its ability to survive plastic strain of a simple type, and can moreover be defined in terms of its basic strain-hardening (q, ψ) characteristic over a limited range. But in a deep-drawing operation the stress system and the critical zone and phase are not simple nor simply defined, and since the critical thinning under biaxial stress is known to vary rapidly with the stress ratio, and the critical stress ratio may itself vary widely according to drawing conditions, there is no reason why the general elongation under simple tension should prove a reliable criterion.

Two independent systematic investigations at Sheffield, covering a full range of appropriate metals have shown that in fact no satisfactory correlation exists between this general elongation and drawability, as measured by the limiting drawing ratio, with either flat or round-headed punches. It is clear therefore that although the form of the strain-hardening characteristic for a metal must in some way determine its drawing properties, and does in fact determine its general elongation, it is an over-simplification to presume a relationship between the two. The conditions in the Erichsen cupping test approximate more nearly than the tensile test to those of a drawing operation; the stress is intrinsically biaxial and the cupping test is in fact a stretch-forming operation of a special kind. For cases in which stretch-forming is the primary operation, and not merely an induced secondary of radial drawing, the Erichsen test is therefore essentially simulative and should be reliable if it proves consistent in operation. Unfortunately its consistency is marred by the facts that the end-point of the test is to some extent a matter of judgment and the test is sensitive to conditions of lubrication. In both these respects Table II is pertinent.

The influence of lubrication in the Erichsen test is of special interest when it is considered in relation to true drawing operations. It will be seen from Table II that an efficient lubricant increases the penetration in the test and at the same time produces a smaller neck diameter at fracture. These lubrication effects are characteristic of a stretch-forming operation; but for a deep-drawing operation it has been shown in Table I that the case is quite different. Lubrication of the punch in a deep-drawing operation does not improve but actually reduces the drawability, and since in deep-drawing the conditions of stretch-forming are consequential rather than basic, there is no reason to assume that a simple stretch-forming test will be representative in other respects.

It is not surprising therefore to find that the Erichsen test does not correlate with deep-drawing tests any better than does the general tensile elongation. The Erichsen test cannot therefore be regarded as satisfactory, except for press operations of which it is clearly simulative, and then only with a procedure standardised as regards lubrication, end-point detection.

THE CUP-DRAWING TEST

The test most closely simulating deep-drawing will embody a representative deep-drawing operation, and no criterion of deep-drawability could be more natural than the limiting ratio of blank to punch diameter for successful drawing. Such a test will be functionally satisfactory provided that: (*a*) it gives consistent results when carried out independently under reputably identical conditions; and (*b*) metal samples follow the same order of merit under the test as in a practice.

It is only recently that a commercial cylindrical cup-drawing test has been developed with claims to serious consideration. This test is based on the drawing of circular blanks with a 2-in. diameter punch, and the criterion of merit is the maximum blank size which can be successfully drawn, measured as a ratio of the punch diameter. It is now known that provided certain reproducible conditions are observed in tool design, setting and operation, satisfactory consistency can be ensured in such a test. The limiting drawing ratio can be reproduced within about 1 per cent.

Whether this test will return the same order of merit between metal samples as any reasonable deep-drawing operation is a more searching question, and one which cannot be answered until it is known whether the cup-drawing operation which constitutes the test itself will always return the same order of merit. In such an inquiry tool clearances, die profile, blank-holding conditions and drawing speed can be regarded as fixed, so that the most important variable is the punch profile, with lubrication demanding at least secondary consideration.

It has been established by numerous and extensive systematic tests that: (1) metal in a soft condition draws somewhat better over a round-headed punch than over one with a flat head, while (2) metal in a relatively hard condition draws much better over a flat-headed punch. (3) With a round-headed punch, the drawability of a given metal is considerably impaired by prior hardening, while (4) with a flat-headed punch the initial condition of the metal has relatively little effect.

These results for the case of commercial aluminium are shown in Fig. 14, for a drawing speed of 0·1 in. per minute, a radial clearance of 23 per cent. and a blank clearance of 6½ per cent.; they are fairly representative of other deep-drawing metals except in one important respect. It will be seen that with partial or inferior lubrication the harder tempers draw better than the soft metal over a flat-headed punch. In the author's experience this case is exceptional, but it is established beyond doubt. Its significance is evident. If a round-bottomed shell is to be produced, soft aluminium is superior to any harder temper; if a flat-bottomed shell, then the harder tempers are superior. In other words, the order of merit of samples of aluminium depends on the particular deep-drawing operation. Hence the correct order can only be obtained by suiting the conditions of test to the destined operation, and no single test of any kind can give an order of merit for deep-drawing generally, because no single order of merit exists.

Table II.—*Effect of Lubrication and End-Point in Erichsen Test*

Material and Temper	Neck or Fracture*	Depth, mm.		Neck Dia., in.	
		Dry	Lub.	Dry	Lub.
Aluminium, Soft	N	10·73	11·47	0·525	0·490
	F	11·25	11·90		
Aluminium, ½ hard	N	8·65	9·14	0·433	0·360
	F	9·37	9·75		
Aluminium, ½ hard	N	8·20	8·89	0·362	0·305
	F	8·97	9·45		
Aluminium, Hard	N	6·84	7·91	0·318	0·265
	F	7·87	8·37		
Rimming Steel, Soft	N	10·50	11·45	0·512	0·496
	F	10·97	11·75		
70 : 30 Brass, Soft	N	12·94	13·90	0·727	0·697
	F	13·33	14·20		
Elect. copper, ½ hard	N	9·02	9·54	0·386	0·334
	F	9·65	9·85		

* N, First appearance of necking; F, Fracture.

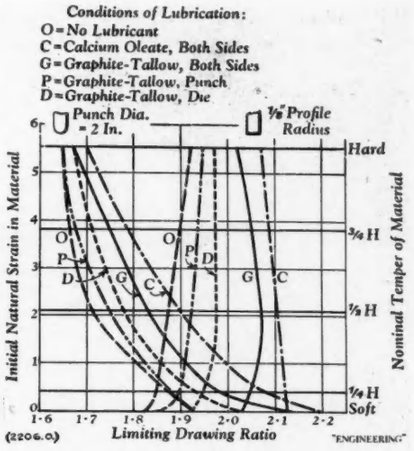

Fig. 14 Limiting drawing ratios for aluminium.

Apart from this anomaly, which seems to be confined to aluminium, though there is evidence of a similar trend in aluminium-magnesium alloys, it can safely be claimed that the softer the condition of a metal, the better will it draw either with a round or flat-headed punch; and since the difference is greater with the round-headed punch, this provides the more discriminating test. Moreover, if efficient lubrication could always be assumed with aluminium, there need be no exception to this rule.

It is suggested, therefore, that at present there is no satisfactory test for deep-drawing properties apart from cup-drawing. This test is sensitive, can be made consistent and if applied with a round-headed punch is capable of high discrimination. The circumstances in which it might be (slightly) misleading are too exceptional to spoil its general claim.

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Correspondence on this British Association paper will be considered for publication in "Engineering."

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DE-SCALING AND BURNISHING

For use in the barrel-finishing of metals, a mineral oxide chip has been developed by Lacrinoid Products, Limited, Gidea Park, Essex. The chips are for de-scaling, de-burring, burnishing or polishing. They are available in nine sizes ranging from 2 in. to ⅛ in. and approach diamond hardness. They can be used in conjunction with any standard polishing compound. It is claimed that, with them, cutting time can be reduced.

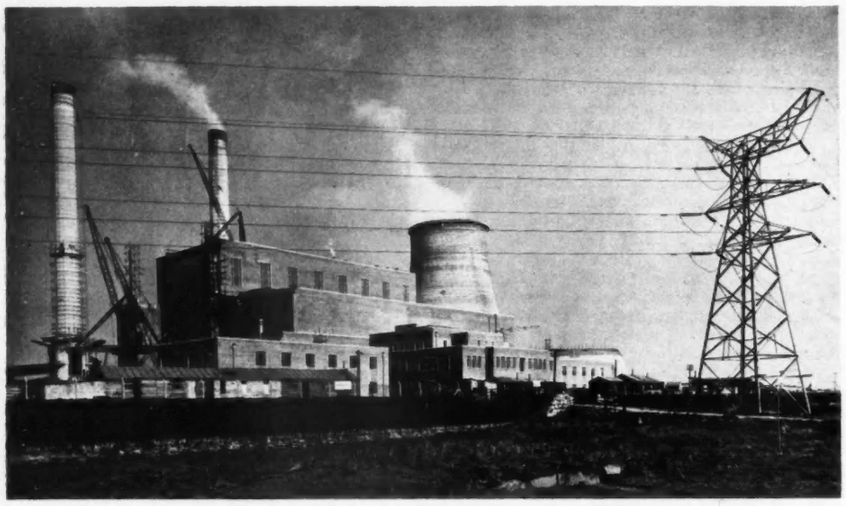


Fig. 1 The Connah's Quay power station is situated between the main Chester-Holyhead railway and the River Dee. It is built on reclaimed saltings.

POWER STATION AT CONNAH'S QUAY

180-MW PLANT FOR NORTH WALES

The building of a power station on the Dee Estuary was originally envisaged by the Chester City Council with a view to replacing their existing small station at Queensferry. It was proposed that this new station should be of some 60-MW capacity and would be located on the existing site.

Following the establishment of the British Electricity Authority on April 1, 1948, the project was taken over, and it was decided that a larger station was required to meet the increasing electrical load in the North Wales area.

The ultimate capacity of the station was set at 180 MW and it was scheduled to be completed in three stages: 60 MW in 1953, a further 60 MW in 1955 and the final 60 MW in 1957. The general design was on the unit principle and each stage would comprise the installation of two 30-MW turbo-alternator sets and two boilers each having an evaporation capacity of 300,000 lb. of steam per hour, the necessary switchgear, coal and ash plant, circulating water pumps, cooling tower and general auxiliary plant.

As the Queensferry site could not accommodate a station of this size, a survey was undertaken and a site chosen on the banks of the Dee about one mile from the ancient port of Connah's Quay. The area, which was about 200 acres, consisted mainly of tidal saltings at approximately 14 ft. above Ordnance Datum level, and was totally covered at spring tides with the exception of a small rock outcrop at the entrance to the site at approximately 34 ft. above Ordnance Datum level. The first task, therefore, consisted in raising the ground level sufficiently for building to commence. A rock formation at a level varying from 12 to 50 ft. deep offered a foundation for piling.

SITE RECLAMATION

The work of site reclamation was commenced on March 22, 1950, when a series of bunds were built around the site. Within the bunds, 4 in. of top soil were removed from the saltings and stored. The bunds adjacent to the river were armoured with willow mattressing and stone to protect them from erosion.

A suction dredger, anchored in an inland lagoon on the opposite side of the river and about a mile from the site, pumped a sand and water mixture through a 26-in. pipe at about 4,500 cub. yards per hour. This was discharged into the area, as may be seen in Fig. 2, and the water allowed to drain away through pipes in the bunds. Approximately 800,000 tons of sand were pumped in this way during the course of nine weeks, raising the ground level by about 8 ft. Above this, a 4-in. thickness of top soil was relaid with the intention of giving a binding surface. A similar method was employed at the steelworks of John Summers and Sons, Limited, which are on the opposite side of the river; this work was described in ENGINEERING, vol. 175, page 525, 1953.

MAIN BUILDINGS

In the case of the buildings, the floors are of beam and slab construction spanning the pile caps, but the cooling-tower pond bottom is designed as a flat slab spanning the single piles, which are spaced in this area at 13 ft. centres. The turbo-alternator blocks are of reinforced concrete construction. They extend from the basement level to the operating floor level and are 26 ft. in height. Each block contains 36 tons of reinforcing steel and 885 tons of concrete. They are completely isolated from the adjoining operating floor by an expansion joint to prevent transmission of vibration.

The building is of steel-framed construction, the main stanchions and roof girders being in 28-ft. bays. The steelwork is of orthodox riveted design, use being made of deep-haunched girders to obviate diagonal bracing. The coal bunkers are of steel with a gunite lining and the bunker for each boiler has a capacity of about 500 tons of coal.

In the main building, which is approximately 390 ft. long by 236 ft. wide, will be housed the six generating sets and their boilers, together with ancillary plant. The walls are generally of 14-in. brickwork, the door and window surrounds and parapets being of reconstructed stone. The majority of the windows are of " Lenscrete " glass concrete construction, while the large continuous lantern light to the turbine bay is also of *in situ* Lenscrete. The lantern lights to the boiler house and turbine house are louvred for ventilation purposes. The roofs are of hollow precast reinforced-concrete units with 1-in. cork insulation and felt and asphalt waterproofing. Internally, the operating floor slab of reinforced concrete is finished with cream Terrazzo tiles in the turbine house and Heather Brown Quarry tiles in the boiler and mill bays. The basement throughout has a granolithic finish. At the operating floor level the turbine-house walls have a blue faience tile dado.

The south block consists of a centre portion which contains the control room, cable rooms, battery rooms, laboratory and administration offices, while in the west wing are the medical treatment rooms, time offices and clocks, lockers, showers, washing rooms and lavatories, and the workmen's and staff canteens and kitchen. The east wing contains the workshop and stores. Heating is by a low-temperature floor-warming system supplied by Panelec (Great Britain), Limited, Redhill, Surrey. Local thermostats control the temperature automatically. Other buildings on the site are the circulating water pump house, the house containing the water-treatment plant, garages and the like. The positions of these can be seen on the site plan, Fig. 3.

The view of the station given in Fig. 1, which was taken from the main Chester-Holyhead road, shows the two 16-sided chimneys and the first of the three cooling towers. The chimneys are each 300 ft. high and 16 ft. clear diameter and rest on 58-ft. high reinforced-concrete stools which are cased in brickwork. The lining is of " Nori " acid-resisting bricks.

As the flow of the River Dee is not sufficient to provide all the water required for cooling, a closed system was necessary. Each of the towers is capable of cooling 2½ million gallons of water from 87·5 deg. F. to 70 deg. F. per hour. They are constructed on a common pond which can be divided to permit operation of one-half of any tower.

The towers are 250 ft. high, 238 ft. in diameter at the bottom and 110 ft. in diameter at the rim. Both towers and pond are built of sulphate-resisting Portland-cement concrete as there is a possibility of high concentrations of sulphates in the pond after it has been concentrated several times.

The cooling-tower pond, 6 ft. 3 in. in depth, holds about 8¼ million gallons of water; spray

Fig. 2 Sand was pumped from a lagoon on the other side of the river to raise the ground level 8 ft. Four inches of soil was laid on top of the sand.

eliminators and de-icing equipment are fitted. Each tower weighs approximately 4,150 tons. The interior of one of the towers during construction is shown in Fig. 4.

BOILER PLANT

There will be six boilers supplied by International Combustion, Limited, each of which has a maximum continuous rating of 300,000 lb. of steam per hour at 625 lb. per square inch and 865 deg. F. These boilers are of three-drum design arranged for corner firing, the furnace being completely water-cooled by finned tubes. They are designed for use with a wide range of East Midlands fuels. Widely-pitched riser tubes between the lower and front drums act as a screen for the superheater and a two-pass convection bank is arranged between the rear upper and lower drums. The furnace-wall tubes are fed by downcomers from the lower drum.

The horizontal self-draining superheater is arranged in two banks to facilitate cleaning. The steam temperature is automatically controlled at the higher loads by altering the tilt of the coal-burner nozzles. A coarse control can be obtained by by-passing the primary bank by means of a damper. With these methods, the final temperature of 865 deg. F. can be automatically maintained within 15 deg. over a load range from 80 to 100 per cent. of the boiler rating. Each boiler has an all-welded economiser, arranged in one bank so that the gas flow between the elements is vertical. There are also plate-type air heaters arranged for contra-flow transfer.

Three Lopulco L.M.13 mills swept by Keith Blackman exhausters grind the coal for each boiler. The hot air passing through the mills dries the coal and is then used as primary air for the burners. Each mill delivers to one burner nozzle in each corner of the furnace, the nozzles being arranged to fire tangentially to an imaginary circle at the centre of the combustion chamber. By varying the vertical tilt of the nozzles the heat absorbed by the furnace walls can be changed, thus regulating the gas temperature entering the superheater pass. Pressure-type oil torches are fitted in the burner casing to ignite the pulverised-fuel stream.

Automatic boiler equipment is provided to control the supply of fuel, the steam pressure, air for combustion and furnace pressure. All the main dampers on the boiler are remote controlled by Lockheed hydraulic mechanisms operated from the unit control panel from which the auxiliary motors are also controlled. Each boiler will be provided with two forced and two induced-draught fans, the former drawing air from above the boiler and inside the boiler house in order to employ some reclaimed heat.

DUST AND SOOT REMOVAL

The flue gases from each boiler are cleaned by a double Sturtevant electrostatic precipitator of that firm's standard tubular type, housed in a concrete casing.

The inlet flue leading the gases from the boiler air heater is an integral part of the concrete casing. The precipitator proper consists of nests of earthed tubular receiving electrodes, and in the centre of each tube is suspended a discharge electrode connected to a unidirectional high-voltage supply.

When the dust-laden gases pass upwards through the tubes, and come under the influence of the ionised field between the two electrode systems, the solid matter in the gases is driven to the tube walls, the clean gases passing out through the top of the tubes into the main outlet flue chamber at the top of the casing. Automatic rapping gear keeps the tubes and the discharge electrodes clear of any dust deposits.

The plant is so designed that the whole of the gas is effectively treated before leaving the precipitator on the way to the stack, and the precipitated dust is collected in hoppers beneath the main body of the precipitators.

The high-tension equipment is of the mechanical rectifier type with a separate high-tension unit for each double precipitator. Each half of the precipitator is connected independently to the high-tension bus-bar, enabling one half of the precipitator to be shut down and, using the common flue, to divert the gases to the other half. The high-tension sets are electrically interconnected in pairs so that either set can operate on either or both precipitators.

The sootblowers are supplied by Ivor Power Specialty Company, Limited, 29 Woburn-place, London, W.C.1. All are electrically operated and are arranged for control from the boiler panel as a fully automatic sequence system. This provides for the selection of any number of sootblowers by means of selector switches mounted on the face of the control panel, initiation of the sequence being effected by means of a single push-button.

There are eight " Gun " type, four " Lance " type and six " Multi-nozzle " type sootblowers per boiler. The Gun sootblowers are arranged to clean the upper sections of the combustion chamber walls (five) and the superheater screen tubes (three); the Lance sootblowers traverse the two banks of the superheater, and the Multi-nozzle sootblowers are arranged to clean between tubes of the convection surface in the rear passes.

The Gun and Multi-nozzle sootblowers are of the standard " Valve-in-Head " pattern with an integral control unit which can be readily adjusted to give variation of the number of blows or variation of sequence pick-up for a succeeding sootblower. The Lance sootblowers, which are virtually Gun sootblowers of increased travel (in this case 11 ft. to 12 ft.) incorporate the feature of oscillatory motion of the nozzle which limits their blowing action to the surface to be cleaned, with consequent steam economy.

Superheated steam is used as the blowing medium at normal boiler outlet conditions, the nozzle pressures being adjusted to 200—250 lb. per square inch. Under present operating conditions blowing is carried out once per day, with the exception of the combustion chamber which is done less often.

COAL AND ASH HANDLING

The coal-handling plant, also supplied by International Combustion Limited, including belt conveyors and wagon tipplers, is capable of dealing with 250 tons of coal per hour. Each of the two coal-wagon tippler plants will discharge at this average rate when handling 20-ton capacity trucks, and the wagons discharge into a common hopper having a capacity of 50 tons of coal. Each tippler platform is arranged to give the weight of wagon before and after tipping.

Coal from the hopper is discharged to a short feeder conveyor which in turn feeds the main conveyor belt. This is designed to deliver coal either to the boiler-house bunkers or to the coal storage area. There are two conveyor belts to the boiler house each capable of handling coal at the rate of 125 tons per hour, and each being capable of working independently. The general arrangement of the conveyors can be seen on the site plan, Fig. 3.

Inside the boiler house, the coal is discharged on to two shuttle conveyors which feed the bunkers, and from there through chutes to the Lopulco mills.

Coal for stocking is delivered to a junction house and from there is discharged for distribution over the storage area by bulldozers. When reclaiming from stock, bulldozers feed the coal

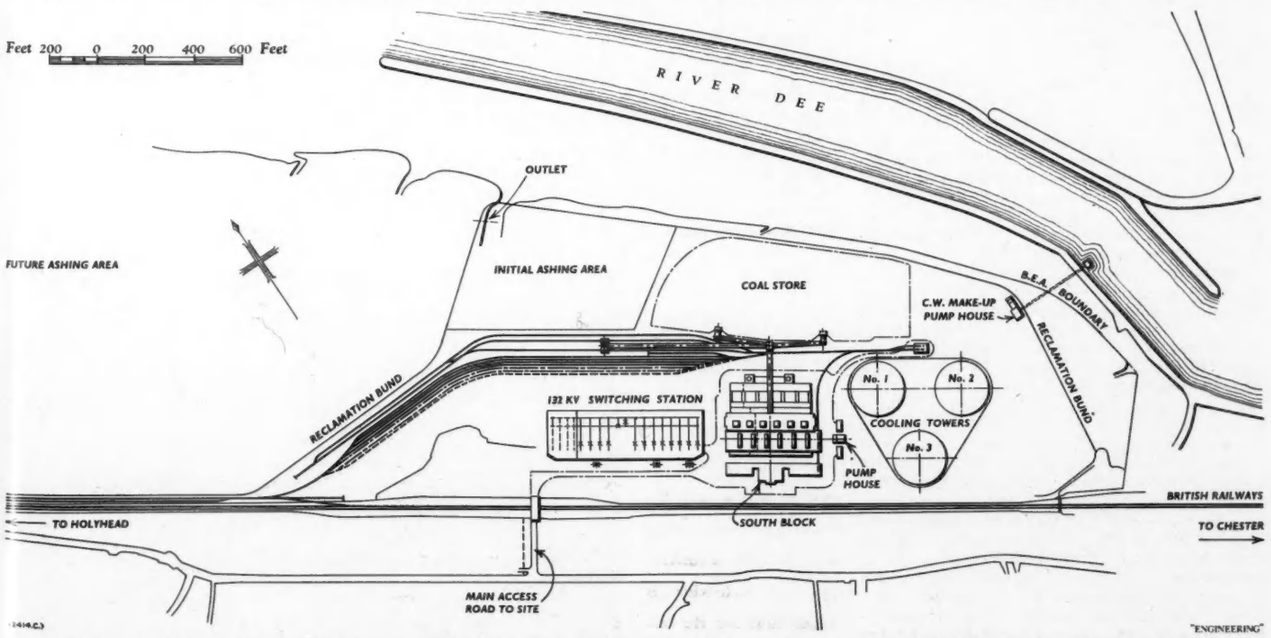


Fig. 3 The 200-acre includes ashing areas which will be usable for 20 years. Only two of the six generating sets are at present in operation.

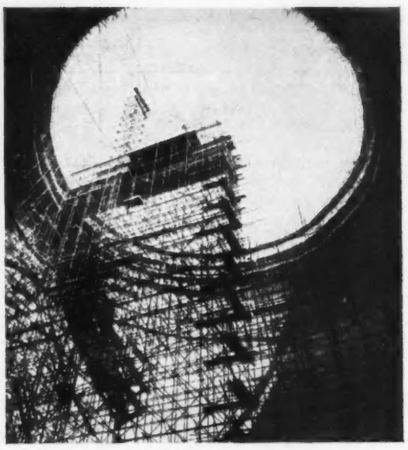


Fig. 4 The interior scaffolding used during the construction of the cooling towers. The towers were necessary as the flow of the Dee is insufficient to provide all the cooling water required.

to hoppers which discharge on to an inclined belt conveyor system for return to the junction house and thence on to the main boiler-house conveyor.

Ash handling is by means of gravity sluice, the ash and dust being discharged from hoppers at the bottom of each boiler and precipitator into the sluices running below basement level. Two sluices will each handle the discharge from three boilers and join to discharge into a swirl pit 15 ft. below ground level. The sluiceways have semi-circular cast-iron liners.

The water for sluicing the ash and dust into the swirl pit is obtained from the return circulating water culverts at a height of 17 ft. above the sluice pumps. There are two 115-h.p. sluice pumps, each capable of pumping 3,300 gallons per minute, one pump being sufficient to sluice the ash and dust discharged from the station boilers if ashing and dusting is done intermittently.

The swirl pit is of concrete construction with a chromium-alloy cast-steel liner fitted with three outlets. From this chamber there are three separate fittings for the suction pipes to each of the three ash slurry pumps.

The 150-h.p. ash slurry pumps, made by Gwynnes Pumps Limited, Lincoln, are each capable of discharging the slurry at a rate of 3,000 gallons per minute through their respective 12-in. pipelines to an open culvert 36 ft. above general ground level. This culvert, called the ash launder, falls at a slope of 1 in 65 to the nearest corner of the initial ashing area. The slurry proceeds down the launder and is discharged on to the ashing area, where it settles out and the water is returned through a controlled outlet to the river. It is estimated that this initial ashing area will suffice for approximately two years.

The present design of the plant is such that the finishing point of the launder can extend to the second ashing area, but it is anticipated that a further swirl pit and booster pump will have to be installed to convey ash to the boundary of the saltings which have been acquired for ash disposal purposes.

One of the features of the Connah's Quay power station is that sufficient low-lying land has been obtained to accommodate the ash and dust for an estimated period of 20 years. This will recover tidal saltings for development.

TURBINE PLANT

Two 30-MW Parsons turbo-generators are installed (Fig. 5), operating with steam at a pressure of 600 lb. per square inch gauge and 850 deg. F. temperature. The turbines are of the two-cylinder tandem type with a double-flow low-pressure cylinder. All the steam entering the turbine passes first through a separate steam-chest mounted alongside the turbine and containing the runaway stop valve, 80 per cent. load valve and 100 per cent. load valve. These valves are oil-operated, the oil being supplied by a pump driven from the turbine shaft. A speed governor, also driven from the turbine shaft, controls the oil pressure in the governor system, hence any variation in the turbine speed immediately affects the opening of the steam admission valves by the change in oil pressure. Motor-driven turning gear is provided on the low-pressure cylinder to keep the rotors revolving during the periods of warming up and cooling down. There are 48 rows of blades on each high-pressure rotor, and 12 rows in the low-pressure sections.

Steam for feed-water heating is tapped from the turbine at four points and by suitable feed-water heaters the condensate from the condenser is heated regeneratively to a temperature of 345 deg. F. when the turbine is developing its maximum rated output.

The steam from the two exhausts of the low-pressure cylinder flows into a double-inlet single condenser. This condenser has a surface of 27,000 sq. ft., with the cooling water arranged to flow in three passes. Air is extracted from the condenser by two two-stage steam-jet operated air-ejectors each capable of handling the full-quantity, while two two-stage motor-driven extraction pumps, of the same capacity, deliver the condensate from the condenser through the air-ejector condensers and the low-pressure feed-water heaters to the boiler feed pump. There is also a quick-start ejector, capable of producing a vacuum of 20 in. of mercury in four minutes. The working vacuum of the condenser is 28·7 in. The boiler feed pumps are placed between the second and third stages of feed-water heating.

Each boiler/turbine unit has an electrically driven feed pump capable of delivering 330,000 lb. of water per hour against a pressure of 880 lb. per square inch. A steam-driven feed pump capable of the same duty is installed with each unit as standby in case of failure of the electrically driven pump and is arranged to start automatically at a predetermined reduction in the feed pressure delivered to the boilers. The electrically-driven sets were supplied by the Harland Engineering Company, Limited, Alloa, Scotland, and the turbine sets by Sigmund Pumps Limited, Team Valley, Gateshead, 11.

CIRCULATING WATER SYSTEM

To condense the exhaust steam from the turbines each turbo-alternator requires 19,500 gallons of water per minute to pass through its condenser. As stated earlier, the minimum flow of the river Dee is insufficient to meet the requirements of six machines, and it was therefore necessary to utilise a cooling tower system.

Water is drawn from the cooling-tower ponds via twin open rectangular culverts, which connect to the circulating-water pump house. Six Sigmund pumps will be installed, each having a capacity of 21,000 gallons per minute, and these discharge to twin ducts which run underneath the whole length of the turbine house. Each condenser has an inlet connection from each of the ducts and an outlet connection into each of the two discharge ducts which return the water to the cooling towers.

Supplies of make-up water for the cooling towers and for the ash and dust sluice water are drawn from the Dee. A piled dolphin, 35 ft from the bank of the river, carries two 20-in pipes, through which water is drawn to the make-up water pumps situated in the pump house upon the river bank. The make-up water is taken at periods of low ebb tides (i.e. when the salt content of the main channel is at a minimum) in order to compensate for losses from the system, and to replace water drawn from the ponds for sluicing purposes. The pump house contains three vertical Gwynnes pumps each having a capacity of 4,000 gallons per minute. The level of the pumps is below the minimum water level in the river, so that the suction branches are always submerged.

WATER TREATMENT PLANT

To eliminate slime-forming growths in the condenser tubes and the growth of marine organisms in the circulating water system, a chlorination plant has been installed by Wallace and Tiernan, Limited, Power-road, London, W.4. The chlorinator used in the scheme has a maximum capacity of 3,000 lb. of chlorine for each 24 hours continuous rating, and is designed to operate intermittently under the control of a central programme clock. The chlorine injector is operated by water under pressure delivered from a booster pump, the water being drawn from the circulating-water return ducts. From the injector of the chlorinator, where the chlorine is intermittently mixed with the operating water, rubber-lined piping conveys the solution to the points of application immediately on the inlets to each condenser. To govern the application of chlorine to each set a hydraulically-operated valve is installed on the connection to each condenser, the valves being controlled from the main central electrical programme clock.

The water to feed the boilers must be of a high degree of purity in order to prevent corrosion and the formation of scale, etc., and a complete water-treatment plant incorporating the latest methods is being installed, which will receive water from the Connah's Quay Urban District Council town main. The treatment is carried out in a mixed bed " Deminrolit " plant, supplied by the Permutit Company, Limited, Gunnersbury-avenue, London, W.4.

The capacity of this plant is 144,000 gallons of treated water each 24-hour day, the normal treatment rate being 9,000 gallons per hour and the reduced treatment rate, with one section out of service, 5,700 gallons per hour. A complete set of instruments is provided with the plant mounted on a panel in the water treatment house.

Water storage tanks of pressed steel construction are mounted on the turbine-house roof. They store water for the cooling system, for the treatment plant and for the automatic fire-

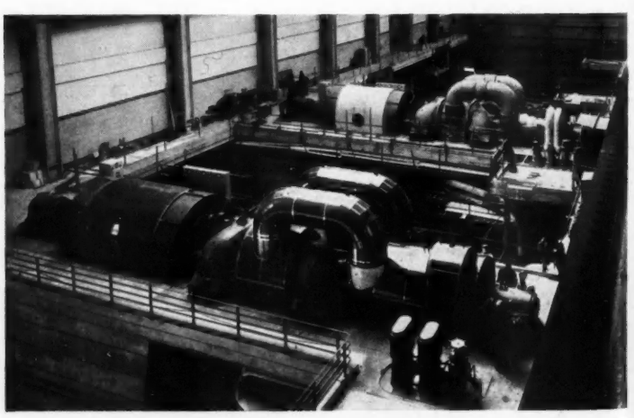


Fig. 5 The first two 30-MW sets in the turbine room. There is room for two more in the present structure, and an extension is being built for the last two.

fighting system. Cooling water for the boiler-steam and water-sampling devices is stored in a tank on the boiler-house roof.

ELECTRICAL PLANT

The Parsons alternators are of the three-phase totally-enclosed ventilated type and each is connected directly to the rotor of the turbine through a multi-claw semi-flexible coupling. The rating is 30 MW, 11·8 kV, 50 cycles at 0·8 power factor. The rotors are of the two-pole cylindrical type running at 3,000 r.p.m. An exciter coupled through a torsion-rod drive at the end of the rotor supplies direct current to the rotor field winding, while a pilot exciter which provides the field current for the main exciter is embodied in the same frame. Cooling is effected by means of a closed air circuit, the air being circulated by two motor-driven fans in the basement and cooled before being admitted again to the ventilation ducts of the generator.

Each generator is connected to a 36-MVA 3-phase 50-cycle step-up Parsons transformer having a no-load voltage ratio of 11·8 to 141·6 kV. The transformer is connected delta on the low-voltage side and star on the high-voltage side.

On-load tap changing equipment of the reactor type, to give a variation of $\pm$ 10 per cent., is connected in the neutral end of the high-voltage winding, and is arranged for local and remote electrical control.

The transformers are forced-draught cooled, and are fitted with two 100 per cent. capacity air-blast coolers, one at each end of the tank. There is no rating under natural cooling conditions, and each cooler is fitted with oil-flow and air-flow indicating equipment, the flow indicators being fitted with electrical contacts.

In addition to the winding temperature being shown on the instruments situated in the marshalling kiosk near the transformer, remote indication is given on the unit control panel, and in the control room of the station.

The supply for certain of the auxiliary services in the power station is taken from two 5-MVA Parsons station transformers. These units are star-star connected with a delta tertiary winding and have a no-load voltage ratio of 132 to 3·45 kV. Some of the transformers will use inhibited oil and research will be carried out on different types to discover what effect they have on oil life.

The main 132-kV Ferguson Pailin switchgear is of the bulk-oil type and has a breaking capacity rating of 2,500 MVA. There is accommodation for six generator units, two station transformer units, and eight feeder units, together with the usual bus-bar coupler and bus-section switch units. Six feeders, all of the overhead-line type, are to be installed.

The station is connected to the 132-kV switchgear compound by a cable tunnel, in which are all the main and multicore cables running between the station and the compound.

Separate rooms have been provided for the control panels, and for the panels mounting the station protective relays. The rooms are adjacent, and are situated in the centre of the administration block.

A laylight with roof lights provides normal lighting for the control room. Cold cathode-type lighting mounted above the laylight provides illumination during the hours of darkness.

The contractors for the reclamation work on the site were the Westminster Dredging Company, Limited, 12 Dartmouth-street, London, S.W.1. Much of the constructional work was carried out by J. Gerrard and Sons, Limited, Swinton, Manchester, and the Yorkshire Hennebique Contracting Company, Limited, Kirkstall-road, Leeds, 4; the latter company's work included the cooling towers. Messrs. L. G. Mouchel and Partners, 38 Victoria-street, London, S.W.1, were the civil engineering consultants for the station and the river intake works.

The station was designed and detailed by the engineers of the former Merseyside and North Wales Division. Since the amalgamation with the North Western Division, Mr. A. R. Cooper, M.I.E.E., has been the divisional controller.

75-C.C. TWO-STROKE PETROL ENGINE

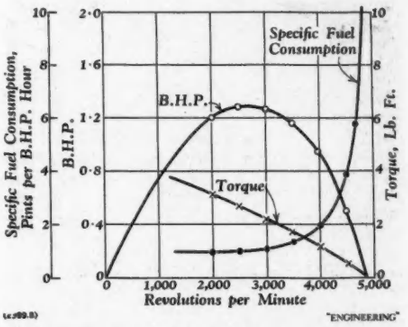
A small air-cooled internal-combustion engine of the spark-ignition type, having a maximum output of 1·28 brake horse-power at the comparatively low speed of 2,500 r.p.m., has been introduced by Vincent Engineers (Stevenage), Limited, Stevenage, Hertfordshire. In the past, this company has been primarily concerned with the design and construction of motor-bicycles. The new engine has one cylinder of 75-c.c. capacity and runs on the two-stroke cycle. It is designed for industrial application, and is suitable for driving compressors, pumps, paint-spraying equipment, milking machines, generating sets, lawn mowers and various types of contractors' plant. Full production is expected to commence next January.

The bore and stroke are 43 mm. and 50 mm., respectively, and the compression ratio is 6 to 1. The normal operating speed of the engine is 2,500 r.p.m., which corresponds to the peak horse-power, as can be seen from the accompanying performance curves, and a fuel consumption of 1 pint per brake horse-power hour.

The connecting rod is cut from flat plate bushed at the small end and the big-end runs on roller bearings which separate it from the crankpin. The rollers are retained by a ground washer and fixing plate. The crankpin and crankshaft are both rigidly fixed to a balance weight type of crank.

Twin-cylinder versions of 150-c.c. capacity using the same components and developing double the power are to be introduced early next year. These will be made with the cylinders in parallel, V, and horizontally-opposed.

With small engines of this type accuracy is of greater importance than with the larger sizes, and certain features of the conventional two-stroke engine such as inlet, transfer and exhaust ports must be controlled to close limits to ensure consistent performance. Variations in the weight and balance of rotating and reciprocating parts such as crank components and connecting rods, which are generally left as cast or forged, with the exception of the actual bearing surfaces, can cause variations in the smoothness of running. To obtain absolute consistency of performance all the gas ports on this single-cylinder engine are precision machined to maintain accuracy of size and location. Similarly, all the rotating and reciprocating parts are machined all over and finished with care to ensure precise balancing, the only exception being the interior surface of the die-cast piston.



Performance characteristics of 75-c.c. engine.

ROTATING-MAGNET MAGNETO

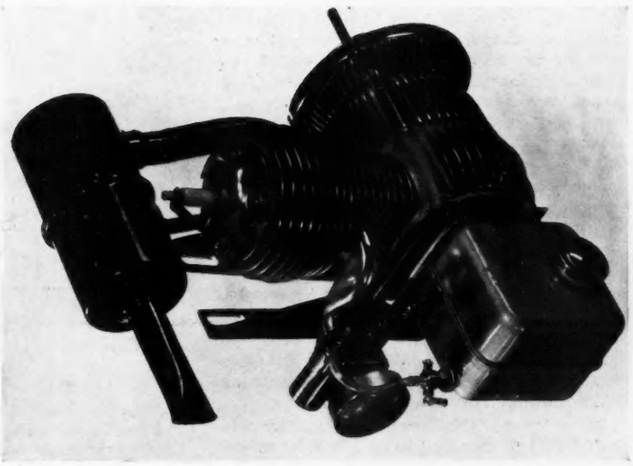
Small industrial power units of this nature are used mostly in applications that call for frequent starting and stopping, making easy starting from cold or hot essential. To ensure this, a special type of rotating-magnet magneto has been incorporated in the design of the engine. It operates off the main shaft, to which it is keyed, and requires no additional bearings. The coils and their windings remain stationary instead of running at high speeds as in the common magneto, an arrangement which eliminates both brushes and slip rings. Due to the magnetic qualities of Ticonel from which the magnet is made, exceptionally reliable operation is stated to have been obtained.

The carburettor, which is of the float type, was designed specially for this engine by the Bletchley Engineering Company, Limited, Slough, Buckinghamshire.

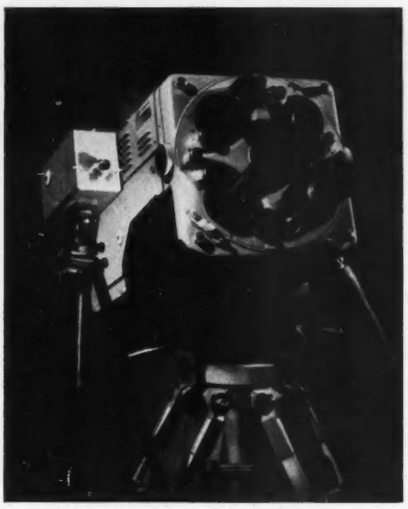
For all normal uses on vehicles the engine's cooling is adequate without any form of fan, but a very simple form of pressed-steel fan is incorporated when the engine is required to run continuously at full throttle for a great many hours without overheating.

Extended development testing has shown that a fuel of only 1 part oil to 52 parts of petrol is required.

The overall weight of 24 lb., which includes the 5-lb. flywheel, has been achieved by the use of light alloy where possible. To dismantle the engine completely it is only necessary to loosen 15 nuts and screws; this frees the cylinder head, connecting rod, main shaft, flywheel, carburettor, inlet stub, petrol tank and exhaust system, and includes the dismantling of the magneto, with the exception of the laminations to the coil, condenser and contact breaker which remain attached to the inner-bearing housing of the engine.



This 1·28-h.p. engine, designed for driving small industrial plant, can be completely dismantled by unscrewing 15 nuts and screws.



Marconi's new industrial television camera shown on the left alongside a typical studio camera for comparison.

INDUSTRIAL TELEVISION CAMERA

Compact Unit of Wide Application

The industrial television equipment which is now being produced by Marconi's Wireless Telegraph Company, Limited, Chelmsford, is intended for such purposes as keeping a continuous watch from a central control office on instruments in widely separated parts of a factory; co-ordinating production lines so as to foresee and avoid incipient bottle-necks; and observing processes and tests which it would be too dangerous to view at close quarters. It can also be used for visual inter-office communication, both on industrial and commercial premises.

The equipment comprises a camera and a control unit. The former measures only 5½ in. by 4 in. by 11⅜ in. and weighs 4½ lb. Its general appearance will be clear from the accompanying illustration, in which it is shown mounted alongside a 140-lb. studio camera.

A Vidicon pick-up tube is employed, the signal from which is capacity-coupled to a three-stage video amplifier and is thence fed into a mixer stage. Here the outputs of the vision and synchronising pulse circuits are combined, and the resultant signal is further amplified. The combined signal is then fed through a synchronising clipper stage, which keeps the horizontal and vertical synchronising pulses equal in amplitude, regardless of varying signal conditions; and thus maintains stable monitor synchronisation. Only the tube, three valves and the associated connections are contained in the camera.

An earthed cathode Hartley oscillator circuit provides any frequency between 54 and 88 megacycles, operation being on one chosen channel. The selected frequency is modulated by the vision signal and is supplied to the control unit through a coaxial cable.

The control unit contains the horizontal and vertical deflection circuits for the pick-up tube and a circuit which prevents the video target coating being burnt in the event of scanning failure. It also includes circuits for providing the necessary wave forms for vertical and horizontal scanning, vertical and horizontal blanking and synchronising pulses.

Power is obtainable from a single-phase supply at 100 to 117 volts or 200 to 250 volts at frequencies of 50 or 60, the loading being 100 watts. The minimum voltage output is 0·1 volt and the output impedance 300 ohms, operation being on either 525 or 625 lines. In use the camera is set up to view the desired scene and is connected by cable to the control unit and thence to the monitor screen or screens, which can be situated up to 2,000 ft. away. After initial setting up the camera is unattended.

* * *

TRANSFORMER OIL WITH OXIDATION-INHIBITING ADDITIVE

Shell-Mex and B.P., Limited, Shell-Mex House, Strand, London, W.C.2, have introduced a transformer oil with an oxidation-inhibiting additive. It is known as Diala Oil B.X. and is recommended for use wherever severe oxidising conditions exist. In some cases it has been in use for four years without attention or renewal. The original neutralisation value has remained constant even when the original oil was not completely flushed out.

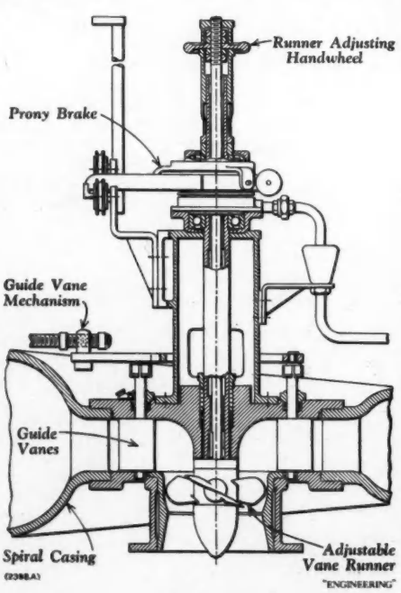
* * *

A KAPLAN-TYPE WATER TURBINE

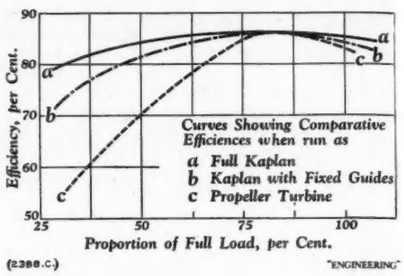
Designed for Instructional Purposes

A Kaplan-type turbine, with an 8-in. diameter adjustable-blade propeller runner and hand-operated guide-vanes, has been added to the range of water turbines designed particularly for instructional purposes at engineering colleges by Gilbert Gilkes and Gordon, Limited, Kendal, Westmorland. It is shown in section and being assembled in the illustrations below.

The propeller blade angle is set by means of a hand wheel at the head of the shaft, when the turbine is at rest, but the guide-vane setting can be adjusted while the turbine is running. Two dummy guide-vanes are provided and these move with the active vanes so that students can see the shape of the vanes and measure the effective



Cross-section through the 8-in. Kaplan water turbine.

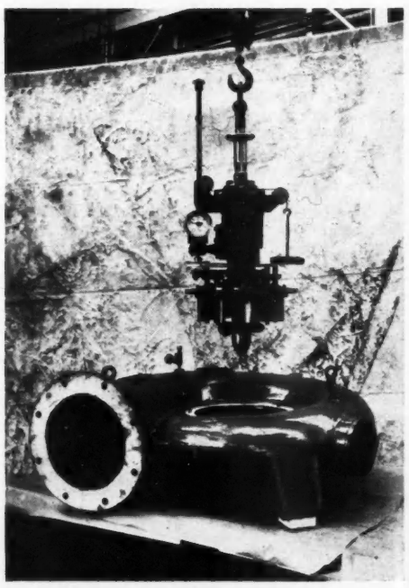


Efficiency curves for the turbine for various adjustments of the blades and guide-vanes.

openings. A full trial on the turbine comprises a series of tests run with various guide-vane openings at each of several settings of the runner blades.

The turbine has an output of about 4·5 brake horse-power when working at a net head of 10 ft., but it is suitable for operating at any head from 6 to 15 ft. It can be supplied with water from an axial-flow or centrifugal pump or from an overhead tank. About 1,500 to 2,000 gallons of water are required per minute according to the head at which the turbine is working. An interesting feature, as may be seen from the photographic illustration, is the ease with which the turbine can be opened up to show the relative setting of the runner and vanes. It takes about 15 minutes to undo the essential nuts, etc., and the guide-vane and runner assembly can then be lifted clear of the casing by an overhead block and tackle.

The power is measured by a delicate Prony brake with a water-cooled drum, and a tachometer and pressure gauge are included as part of the machine. The efficiencies obtained are depicted above. Curve *a* indicates the efficiency as a full Kaplan turbine with the runner blades and vanes adjusted to give the maximum efficiency at any power. Curve *c* indicates the efficiency when the set is run as a fixed-blade propeller turbine, and curve *b* the efficiency when the guide vanes are set fully open and the angle of the runner blades adjusted according to variations occurring in the loads.



The turbine has been designed for easy dismantling so that it may be readily examined by students.

WATERWORKS RECONSTRUCTION SCHEME AT EXETER

RUNNING COSTS REDUCED BY WATER-DRIVEN PUMPING STATION

The whole of the water supply for the City of Exeter is collected at Pynes Waterworks, where it is purified before being pumped to the service reservoirs for distribution to the city by gravity. The greater part of the supply is drawn from the River Exe at a rate which is limited by Act of Parliament to 5,400,000 gallons a day, the river intake being about 3,000 yards upstream of the waterworks. After treatment, the water is taken from the clear-water tank and pumped through five pipelines to the service reservoirs: 18-in. and 12-in. mains, via Cowley-road, to Danes Castle reservoir at 200 ft. above ordnance datum; two 14-in. mains to the intermediate reservoir at 356 ft. above O.D.; and a 9-in. main to the Barley-lane reservoir at 375 ft. above O.D. An additional reservoir at Marypole Head, 360 ft. above O.D., is filled by pumping from the intermediate reservoir.

To meet these requirements a new pumping station has been built to replace old equipment which had ceased to give economic operation. The floor level of the new station is at 53·50 ft. above O.D. and replacement has been completed after nearly three and a-half years' work without interfering with the regular supply to the city.

The main considerations affecting the design of the new station were that all the machinery should be housed in a single building; water power should be used to the fullest extent for driving the pumps, because of the saving in running costs; the extra output required should be provided by electrically-driven pumps; stand-by Diesel-engine-driven pumps should be installed for use in case of failure of both water and electrical power, and also a stand-by Diesel-engine-driven generator to supply current for the filter-plant motors in case the electricity supply should fail.

Detailed measurements for 12 months of the river, leat and tailrace levels showed that the new turbines should be designed for a maximum discharge from the leat of 350 cub. ft. per second, with an average fall from headrace to tailrace of 8 ft. In a year of average rainfall, it is thought that the turbines will be self-sufficient for eight months out of twelve. It was decided to install two turbines of identical type, driving centrifugal pumps through speed-increasing gears; one turbine, for the high-service supply, has an output of 1,150,000 gallons a day, the other, for the low-service supply, an output of 2,160,000 gallons a day. To compensate for the shortage of power water in the summer, or in years of low rainfall, these pumps have also been provided with motor drives, principally to boost the turbines but sufficient in size to drive the pumps should no water be available.

To obtain the additional output required from the station, three motor-driven pumps (one for low service, two for high service) have been installed, comprising one 170-h.p. pump from the old pumping station, and two new 205-h.p. pumps.

The Diesel-engine stand-by plant consists of one high-service and one low-service pump, and an alternator to produce current for the 36 8-ft. diameter Bell filter motors and other miscellaneous services. It has also been decided to retain an existing Worthington-Simpson steam pump as an additional stand-by plant for the high-service supply, but provision has been made in the new pump-house for the installation of an additional Diesel-engine-driven pump when the steam pump has to be scrapped. The main contractors for the pumping plant were W. H. Allen, Sons and Company, Limited, Bedford, the turbines being built for them by Gilbert Gilkes and Gordon, Limited, Kendal, Westmorland. The pump-house is a rectangular building about 128 ft. long by 42 ft. wide, brick built with cavity walls, enclosing a steel frame designed to support an overhead travelling crane.

The work of reconstruction was commenced in May, 1951, with excavations for the new pump-house and the simultaneous demolition of two old turbine houses. Installation of the plant began in January, 1953, with the erection of the 6-ton overhead crane which was then used to handle the pumping machinery. The low-service turbine was first run on load in October, 1953, and the high-service unit in the following November. All the main units were completed and were running under load by April. The new works were designed and constructed under the direction of the City Surveyor and Water Engineer, Mr. J. Brierley, A.M.I.C.E., and have been completed for a cost of rather less than £124,000.

MARCHWOOD 480-MW POWER STATION

ALTERNATIVE COAL AND OIL FIRING

The Marchwood power station of the British Electricity Authority, the foundation stone of which was laid by the Lord Lieutenant of Hampshire (the Duke of Wellington, K.G.), on Wednesday, September 8, is situated on the western bank of Southampton Water. It is designed for an ultimate capacity of 480 MW, and is interesting from the fact that it will be the first major plant in this country to utilise either pulverised coal or oil as fuel. The supply of the latter will be facilitated by the proximity of the station to the Fawley refinery. The station is expected to be finished by 1962.

The reinforced-concrete foundations are supported on over 10,000 reinforced-concrete piles, and the buildings are steel framed structures with walls of troughed aluminium sheeting. There will be two circular reinforced-concrete chimneys, each 425 ft. high. The consulting civil engineers are Sir Wm. Halcrow and Partners, Caxton-street, London, S.W.1, and the principal civil engineering contractors are Sir Robert McAlpine & Sons, Limited, Park-lane, London, W.1.

Coal will be brought in by water to a 760-ft. wharf and will be delivered to the boiler house by two 10-ton portable electric cranes, manufactured by Stothert and Pitt, Limited, Bath, and a twin-belt conveyor system with a capacity of 300 tons per hour for which John Thompson (Conveyors), Limited, Wolverhampton, were responsible. The oil will be supplied to three storage tanks, each of which will have a capacity of 10,000 tons. These tanks and the associated pipe work will be heated by steam from three La Mont boilers with an output of 30,000 lb. per hour.

STEAM-RAISING PLANT

The steam-raising plant will eventually consist of eight water-tube boilers, which are being constructed by John Thompson Water Tube Boilers, Limited, Wolverhampton, and each will have an output of 550,000 lb. of steam per hour at a pressure of 915 lb. per square in. and a temperature of 925 deg. F. Each boiler will be fired from two Thompson Kennedy pulverisers through 12 side-fired burners. Alternatively, firing will be effected at a temperature of 320 deg. F. through 16 British Combustion Equipment oil burners from two pumps each with a capacity of 12 tons per hour. The boilers will be equipped with John Thompson tubular air heaters and Sturtevant electrostatic precipitators, as well as with Howden forced and induced draught fans. The ashes will be handled by Hydrojet and the dust by Hydrovac equipment for which Babcock and Wilcox, Limited, Farringdon-street, London, E.C.4, will be responsible.

The generating plant will consist of eight English Electric three-cylinder impulse reaction turbines with double-flow low-pressure cylinders. These turbines will be coupled to 60-MW. hydrogen-cooled alternators, which will generate three-phase current at 11·8 kV when running at 3,000 r.p.m., the turbines exhausting into two twin-flow surface condensers of Hick, Hargreaves manufacture with a cooling surface of 55,000 sq. ft. The feed-heating plant, which is also being manufactured by Hick, Hargreaves and Company, Limited, Bolton, will consist of three low-pressure and two high-pressure heaters, the third low-pressure heater being of the high-level de-aerating type. There will be 12 Sulzer feed pumps, each with an output of 650,000 lb. per hour at a pressure of 1,280 lb. per square inch. Cooling water will be supplied by eight pumps with an individual output of 55,000 gallons per minute, which are being manufactured by Drysdale and Company, Limited, Glasgow.

ELECTRICAL EQUIPMENT

The generating pressure will be stepped up to 132 kV by 72-MVA transformers, which are being manufactured by Ferranti, Limited, Hollinwood, while the station will also be equipped with 7·5-MVA, 132/3·42-kV station transformers, 6-MVA, 11·8/3·42-kV unit transformers and 3·3-kV/433-volt auxiliary transformers for which the Yorkshire Electric Transformer Company, Limited, Dewsbury, and South Wales Switchgear, Limited, Blackwood, Monmouthshire, will be responsible. The 132-kV switchgear, which is being supplied by the British Thomson-Houston Company, Limited, Rugby, will be of the bulk oil volume type and will have a rupturing capacity of 2,500 MVA. The lower-voltage switchgear, which is being supplied by the English Electric Company, Limited, Kingsway, London, W.C.2, will be of the air-break pattern.

The installation has been designed by and is being erected under the supervision of the staff of the Southern Division of the British Electricity Authority, of which Mr. R. H. Coates is the Controller.

LAUNCHES AND TRIAL TRIPS

M.S. "NYMPHE."—Single-screw cargo vessel, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for the Compañia Armadora Transoceanica S.A., Panama. Main dimensions: 435 ft. between perpendiculars by 59 ft. by 39 ft. 2 in. to upper deck; cargo capacity, 616,300 cub. ft.; deadweight capacity, about 9,950 tons on a summer draught of 26 ft. with tonnage opening open, and about 11,000 tons on a draught of 27 ft. 9 in. with tonnage opening closed and additional scantlings in use. N.E.M.-Doxford four-cylinder single-acting two-stroke opposed-piston oil engine, developing 4,400 b.h.p. at 115 r.p.m., constructed by the North-Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Trial trip, September 1.

S.S. "DAVID POLLOCK."—Single-screw self-trimming collier, built by Hall, Russell & Co., Ltd., Aberdeen, for the North Thames Gas Board, London, W.8. (Managers: Stephenson Clarke, Ltd., London, E.C.3.) Main dimensions: 320 ft. between perpendiculars by 46 ft. by 22 ft. 4 in.; deadweight capacity, about 4,600 tons on a draught of 20 ft. Triple-expansion steam engine of reheat design, developing 1,275 i.h.p. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Steam generated by two oil-fired cylindrical boilers). Trial trip, September 2.

S.S. "HAUSTELLUM."—Single-screw oil tanker, built and engined by Hawthorn Leslie (Shipbuilders) Ltd., Hebburn-on-Tyne, County Durham, for Shell Bermuda (Overseas) Ltd., London, W.C.2. Main dimensions: 557 ft. overall by 69 ft. 3 in. by 39 ft. to upper deck; deadweight capacity, about 18,000 tons. Double-reduction geared steam turbines, developing a maximum of 8,250 s.h.p., and two Foster Wheeler water-tube boilers. Trial trip, September 7 and 8.

M.S. "LOTTE SKOU."—Single-screw cargo vessel, with accommodation for ten passengers, built and engined by Burmeister and Wain Ltd., Copenhagen, for the joint ownership of Ove Skou Ltd. and The Shipping Co. of 1937 Ltd., both of Copenhagen, Denmark. Main dimensions: 365 ft. between perpendiculars by 55 ft. 6 in. by 35 ft. 4 in. to upper deck; deadweight capacity, 6,550 tons on a draught of 24 ft. 3 in.; cargo capacity, about 395,000 cub. ft. (bales). B. and W. nine-cylinder single-acting two-stroke Diesel engine, developing 5,400 b.h.p. at 150 r.p.m. Engine arranged for burning Diesel and heavy oil. Launch, September 8.

M.S. "PATHFINDER."—Twin-screw pilot vessel, built by Philip and Son, Ltd., Dartmouth, for the Corporation of Trinity House, London, E.C.2. Main dimensions: 157 ft. between perpendiculars by 30 ft. by 14 ft. Two six-cylinder Diesel engines, each developing 500 b.h.p. at 325 r.p.m. in service, constructed by British Polar Engines, Ltd., Glasgow. Launch, September 13.

M.S. "COLLENA."—Single-screw trawler, built by Cochrane and Sons, Ltd., Selby, Yorkshire, for J. Marr and Son, Ltd., Fleetwood, Lancashire. Main dimensions; 127 ft. 6 in. between perpendiculars by 26 ft. 6 in. by 13 ft.; gross tonnage, about 400. Five-cylinder direct-reversing Diesel engine, developing 700 b.h.p. at 230 r.p.m. in service, constructed by British Polar Engines, Ltd., Glasgow, and installed by Amos and Smith, Ltd., Hull. Launch, September 14.

M.S. "STAHOLM."—Single-screw cargo vessel, with accommodation for four passengers, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend-on-Tyne, for A/S Havtank and A/S Hav (Managers: Helmer Staubo), Oslo, Norway. Main dimensions: 430 ft. between perpendiculars by 60 ft. 6 in. by 38 ft. 9 in. to upper deck; gross tonnage, 5,520; general cargo capacity, 504,756 cub. ft. (bale); deadweight capacity, 9,000 tons on a draught of 25 ft. 6 in. Wallsend-Doxford five-cylinder two-stroke opposed-piston oil engine, developing 5,000 b.h.p. at 108 r.p.m. in service, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 14½ knots. Trial trip, September 15.

M.S. "KHUZISTAN."—Single-screw cargo liner, with accommodation for five passengers, built by John Readhead and Sons, Ltd., South Shields, for the Strick Line Ltd. (Managers: Frank C. Strick & Co., Ltd.), London, E.C.3. Main dimensions: 450 ft. between perpendiculars by 58 ft. 6 in. by 32 ft. 2 in. to upper deck; deadweight capacity, 10,000 tons on a draught of about 25 ft. 8 in. N.E.M.-Doxford four-cylinder opposed-piston oil engine, developing 4,400 b.h.p. at 115 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, about 13 knots. Launch, September 15.

A MODERN STEAM ENGINE

LIGHT ADAPTABLE UNIT FOR RURAL USE IN UNDER-DEVELOPED COUNTRIES

In his introduction to a demonstration of a light steam engine designed to serve a variety of purposes in places where other sources of power are limited or non-existent, the Rt. Hon. The Earl of Halsbury, F.R.I.C., F.Inst.P., Managing Director of the National Research Development Corporation, said that the engine had been developed by Ricardo and Company (1927), Limited, 21 Suffolk-street, London, S.W.2, and the N.R.D.C., 1 Tilney-street, London, W.1, for use particularly in those countries which were many years behind western nations in technological progress. Known as the N.R.D.C.-Ricardo steam-operated prime mover, the engine had been built to solve the problem of providing agricultural communities in Commonwealth and eastern countries with power for such requirements as irrigation, workshops and the milling of grain, without recourse to electrical energy or fuels and lubricants which might be unobtainable or in short supply. (Drawings of the engine and boiler appear in Figs. 2 and 3.)

The engine, which was simple in construction and easily maintained, would, he believed, compete successfully with corresponding Diesel engines with regard both to output and to cost of production. It was considered that for production in quantity a model of 5 h.p. would be most suitable, but the prototype engines which had so far been made and which were to be demonstrated on this occasion were of 2½ h.p.

RURAL VERSATILITY

The demonstration, which was held in the grounds of the Sondes Place Research Institute, Dorking, was arranged in order to display some of the qualities and applications of the engine, so that companies might be encouraged to undertake its production on a large scale. The exhibits included a pumping unit operating against a head of 30 ft., a corn-grinding mill, a machine shop, a hospital radiographic unit and a tropical bungalow with numerous electrical fittings and a refrigeration plant. All these items were driven by prototype models of the N.R.D.C.-Ricardo prime mover. The display represented the results of development work and exhaustive field tests carried out on the engine by the N.R.D.C. under the supervision of Brigadier M. H. Cox.

To illustrate the application of the engine to pumping and irrigation, it had been connected as shown in Fig. 1 to a centrifugal pump, and had been run for 800 hours under service conditions resembling those to be found in India. During 500 hours it had operated under full load at 1,950 r.p.m. with a 3-in. diameter suction and a 2½-in. delivery pipe, discharging 5,000 gallons of water an hour at a head of 30 ft. and had delivered in that time 11,000 tons of water. On several occasions the engine had run continuously for 24 hours, except for short intervals when the boiler was blown down to remove accumulated solids. Engine wear had been negligible during the test and oil consumption, which depended on the nature of the oil used, had been approximately 0·004 pints per horse-power hour.

MULTI-PURPOSE TRAILER UNIT

Other exhibits included a grain mill with an output of 150 lb. of flour per hour when grinding hard barley for cattle feed; a rural workshop operating on power supplied by the N.R.D.C.-Ricardo engine illustrated in Fig. 4, which also drove a generator for charging car batteries; and a trailer-mounted steam unit used in this case for sprinkler irrigation and log sawing. The sprinkler could provide 13 acres with the equivalent of 1 in. of rainfall in ten 12-hour days and the chain saw connected to the steam plant by a 25-ft. flexible-shaft drive was capable of cutting through a 12-in. diameter log in less than a minute. The whole unit, which could be towed by a jeep, weighed 8 cwt. and could be adapted for use with other equipment such as oil expellers and sugar-cane crushers which would likewise be carried on the trailer.

Another example of the engine's applications was a timber-seasoning plant in which the power unit drove an air-circulating fan and also supplied exhaust steam to heating coils. In the plant exhibited this source of heat was sufficient, but, if required, more heat could be obtained by utilising the flue gases. The capacity of the plant demonstrated, with the 2½-h.p. steam unit, was 250 cub. ft. and the exhaust steam circulated was 75 lb. per hour at a pressure of 3 lb. per square inch.

HEATING AND REFRIGERATION

The steam-supply provided by this form of power unit represents a considerable advantage in dairies, hospitals and other establishments which employ sterilising equipment, and in the extraction of essential oils from farm and forest products where a source of steam is also necessary. If an internal-combustion engine were used for these purposes, separate steam-raising plant would be required.

Moreover, as distinct from an internal-combustion engine, a steam engine has a large overload capacity and will not stall; when the load is reduced, the engine automatically restarts.

Brigadier Cox reported that work was proceeding on additional steam-driven equipment for use in tropical territories. Not yet fully developed was an air-conditioning plant, in which an

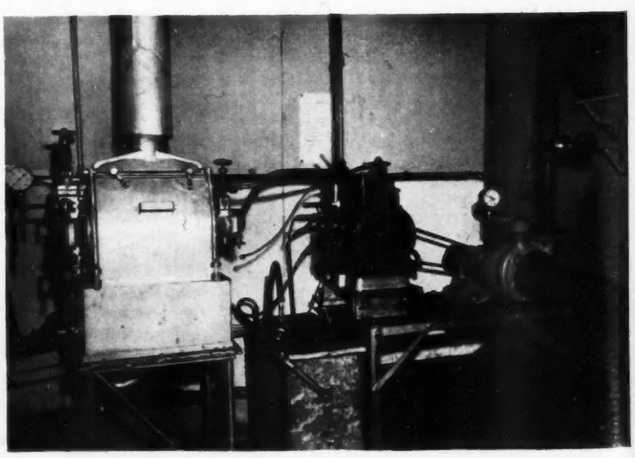


Fig. 1 For irrigation the engine can be coupled directly to a centrifugal pump. The unit shown here can supply 5,000 gallons of water per hour from a depth of 30 ft.

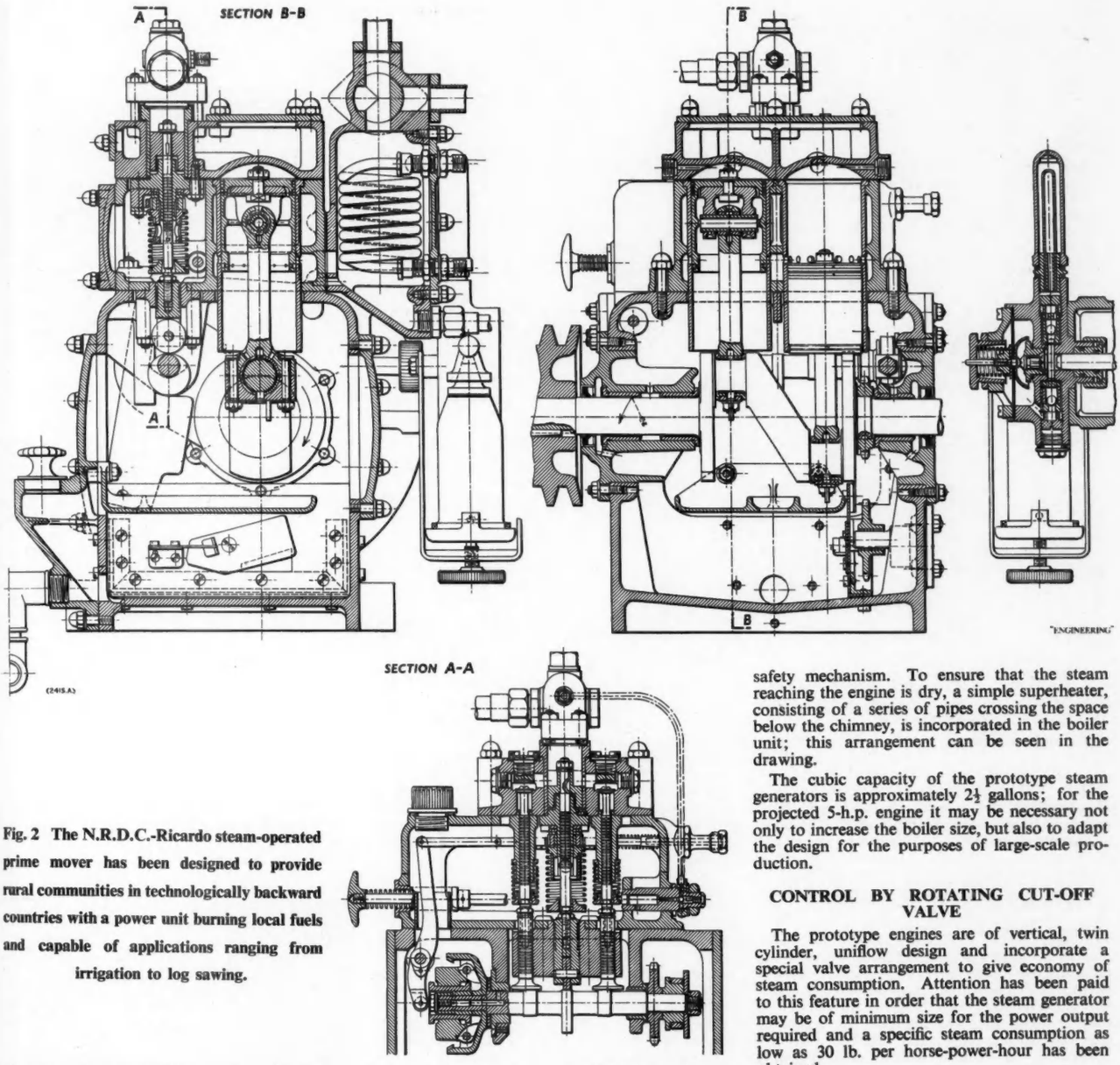


Fig. 2 The N.R.D.C.-Ricardo steam-operated prime mover has been designed to provide rural communities in technologically backward countries with a power unit burning local fuels and capable of applications ranging from irrigation to log sawing.

absorption type of refrigerator employing the stack heat from the steam unit would, it was believed, not only serve to lower the temperature in an average-size bungalow by between 10 and 15 per cent., but also reduce the atmospheric moisture content. The engine itself would supply power for air circulation. Other applicances designed for domestic purposes included water-heating systems and generating sets.

THREE-UNIT CONSTRUCTION OF PRIME MOVER

The prime mover which is the basis of the equipment so far described consists of three units which can be transported separately and assembled on site; these are: the furnace, the steam generator and the engine. As in the arrangement shown in Fig. 1, the engine can be situated at some distance from the other two components and this may frequently simplify installation; heat loss in the steam connections must then, however, be taken into account and appropriate lagging provided. The engine of the version illustrated in Fig. 4 is set adjacent to the boiler; the furnace is directly beneath the boiler.

The furnace is of simple design and can be made of materials easily obtained in all countries. Although a furnace of standard size can be used to deal with all types of fuel, in practice it is preferable to employ a small and compact model for fuels such as coal, peat or wood; for burning such agricultural waste as sugar-cane trash or cotton stalks, a slightly larger furnace with an extended grate area is more suitable.

Fuel is added to the furnace through the bunker projection at the front of the unit and the models exhibited were fired with various fuels including coal, peat and wood.

CAST LIGHT-ALLOY DRUM BOILER

The steam generator, a drawing of which appears in Fig. 3, consists basically of a cylindrical drum with deep external ribs, end covers secured by studs and suitable cowling. The drum is a light-alloy casting and the ribs give strength and efficient heat transfer from the hot gases which circulate round it. Resistance to corrosion in all circumstances is one of the qualities for which the alloy employed has been selected.

The generator is supplied with water by an engine-driven pump and the water is maintained at a constant level by means of a float, which, in addition to controlling the action of the feed-water inlet valve, incorporates a low water-level safety mechanism. To ensure that the steam reaching the engine is dry, a simple superheater, consisting of a series of pipes crossing the space below the chimney, is incorporated in the boiler unit; this arrangement can be seen in the drawing.

The cubic capacity of the prototype steam generators is approximately 2½ gallons; for the projected 5-h.p. engine it may be necessary not only to increase the boiler size, but also to adapt the design for the purposes of large-scale production.

CONTROL BY ROTATING CUT-OFF VALVE

The prototype engines are of vertical, twin cylinder, uniflow design and incorporate a special valve arrangement to give economy of steam consumption. Attention has been paid to this feature in order that the steam generator may be of minimum size for the power output required and a specific steam consumption as low as 30 lb. per horse-power-hour has been obtained.

The valves, which are shown in Fig. 2, are operated by a single camshaft, which drives two steam-inlet poppet valves and a cut-off valve common to both cylinders; exhaust is provided by vents in the cylinder walls. The cut-off valve, which rides on an eccentric cam, is also capable of rotation about its axis, a movement which is controlled by a rack acting in conjunction with a pinion on the valve stem. The rack is linked to a governor fitted to the camshaft. The upper end of the valve consists in effect of a piston containing two helical step recesses, which correspond with two oblique elliptical openings in an outer fixed sleeve. The piston can slide in the outer sleeve and when a recess and an opening coincide steam passes to the poppet valves.

The action of the valve is such that the quantity of steam passing to the cylinders is subject to accurate control. As the load on the engine alters, the tendency for the speed to change causes a movement of the governor; a corresponding lateral displacement of the rack, effected through the governor linkage, rotates the valve, thus advancing or retarding the point of cut-off. Consequently, as greater demands

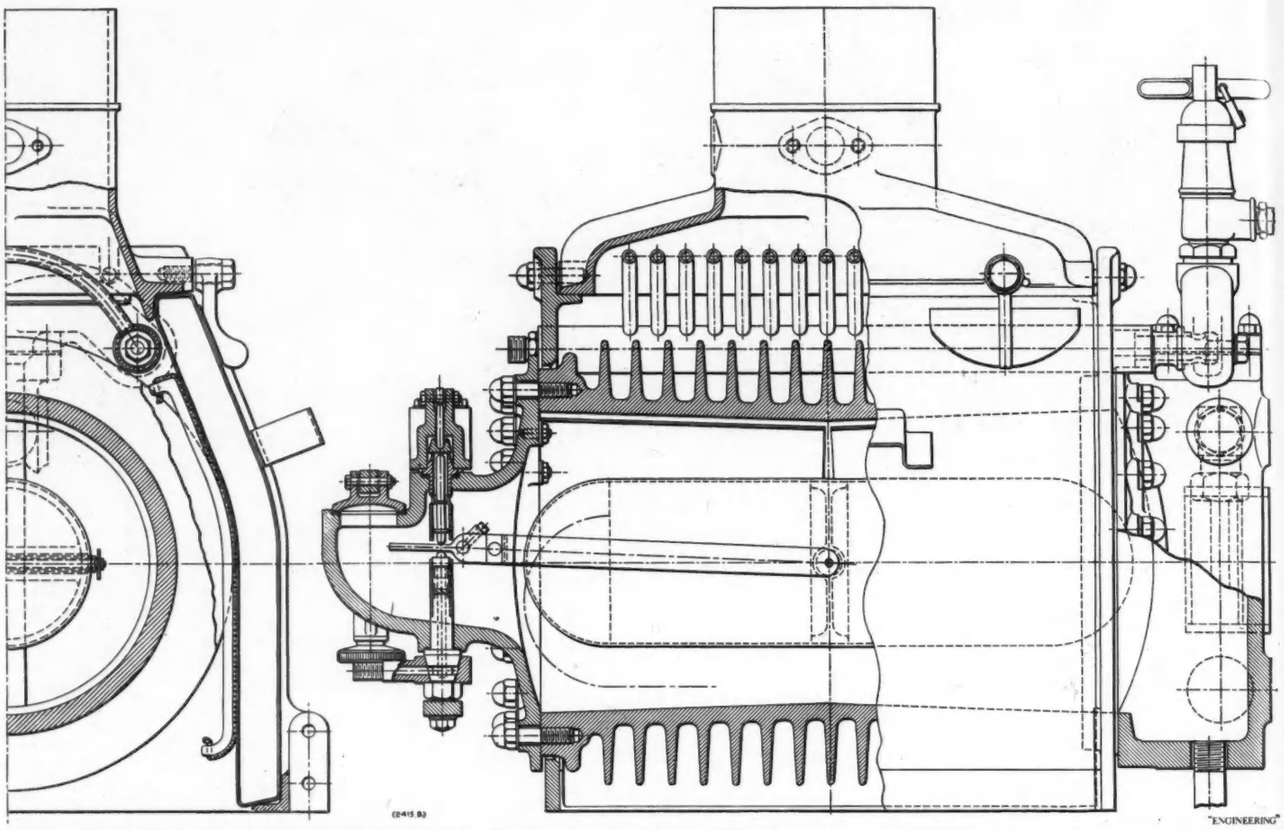


Fig. 3 The engine has a valve system which minimises steam consumption, thus enabling the steam generator, shown here, to be of small dimensions. The boiler drum is cast in light alloy and ribbed to improve strength and heat transfer.

are made on the engine, the supply of steam to the cylinders is increased and the speed is thus maintained approximately constant. Hand adjustments to the speed are made by means of a mechanism incorporated in the governor crank.

COMBINED OXYGEN AND TEMPERATURE RECORDER

Indicating Stack Losses

A recent addition to the range of boiler-house control instruments by George Kent, Limited, Luton, Bedfordshire, is a combined oxygen and temperature recorder, designed primarily to provide the boiler-house engineer with an easily-read indication of the stack losses. The new instrument is a counterpart of the Kent combined CO_2 and temperature recorder, but is fitted with a paramagnetic oxygen analyser in place of the CO_2 analysis cabinet.

The oxygen analyser measures the oxygen concentration in the flue gases, which bears a close relation to the quantity of excess air fed to the furnace, and gives a more accurate record of combustion conditions than does the CO_2 recorder, since the optimum CO_2 content of flue gases can vary between quite wide limits for variations in fuel. The oxygen analyser has, moreover, a much faster response.

The recorder in the new instrument is of the two-point form, the change-over from one point to the other being entirely automatic. The oxygen record is on the left-hand side of the chart and the temperature record on the right.

The combined oxygen and temperature recorder has two entirely separate measuring circuits. The maximum range of oxygen in flue gas that can be accommodated is 0—15 per cent., and the temperature circuit is of the three-wire resistance-thermometer type with a standard range of 0 to 750 deg. F. High instrument sensitivity with a robust galvanometer system is obtained by the use of the latest Kent vibrating-reed synchronous converter.

CONDENSATE SEPARATION

Other features of the engine include a feed-water heater and a pump, shown in the drawing (Fig. 2) at the right of the engine, and also a splash lubrication system; there is in addition an arrangement whereby any condensate which enters the crankcase and mixes with the lubricating oil may be drawn off and separated.

The prototype engine, which has a 2½-in. stroke and cylinders 2¼ in. in bore, develops 2½ brake horse-power at 1,250 r.p.m. when supplied with steam at 150 lb. per square inch gauge pressure. There is a considerable capacity for overload, and an output as high as 3½ h.p. can be safely obtained intermittently. The engine is robust and adaptable and totally enclosed in a dust- and water-proof casing.

The operation of the engine is simple and may be performed by unskilled labour; it is necessary, however, since fuel must be added at fairly short intervals, for someone to be in constant attendance. Not only can it be run on local fuels but also on vegetable lubricating oils; one prototype model has been tested over long periods with castor oil as a lubricant.

SOLAR ENERGY AND IRRIGATION

Already enumerated are various fuels suitable for use with the N.R.D.C.-Ricardo engine; it has, however, a special application where crop fuels are to be cultivated. The most efficient method for converting solar energy into useful power so far discovered is that of photo-synthesis, and in many parts of the world the growing of such vegetational fuels as eucalyptus trees may prove the best source of power for irrigation purposes. Consequently, in countries with vast areas to irrigate artificially, the steam engine can still have a very wide and important application. This is especially the case where processed liquid fuels are expensive and skilled labour unobtainable.

Fig. 4 Applications of the N.R.D.C.-Ricardo engine include power for machine shops and corn mills, air-conditioning plant and electric-power generation.

Designed for a maximum payload of 24 tons, this eight-wheeled articulated tractor and trailer unit has a width of 8 ft. and incorporates a turntable of new design. Scammell Lorries, Ltd.

COMMERCIAL MOTOR SHOW

LIGHT, MEDIUM AND HEAVY CARRIERS

Continued from page 411

Our first article on the commercial vehicle industry's show at Earls Court, London, dealt with one vehicle of particular interest and developments in light-weight construction. The article this week deals with load-carrying vehicles ranging from a light 3-wheeled van to a heavy tractor and trailer unit.

8-FT. 24-TON ARTICULATED LORRY

Scammell Lorries, Limited, Watford, Herts., have produced a vehicle to meet the proposed Motor Vehicle (Construction and Use) regulations. It is a tractor and semi-trailer designed for a maximum payload capacity up to 24 tons gross weight having eight wheels and a body 8 ft. wide. The overall length of this articulated vehicle is 35 ft. The cab as can be seen from the illustration above, though modernised, still bears the traditional Scammell lines. Larger doors have been fitted and the insulation improved. The front wings have been re-styled and the headlamps built-in.

The engine normally fitted in the 15-ton tractor is a Gardner 6LW Diesel designed to give 112 brake horse-power at 1,700 r.p.m. and 358 lb. ft. torque at 1,300 r.p.m. Alternatively, a Scammell-Meadows Diesel engine can be installed which develops 125 brake horse-power at 1,750 r.p.m. with a maximum torque at 1,000 r.p.m. of 420 lb. ft.

A constant-mesh gear box having a 1·5 to 1 overdrive top gear and a 6 to 1 ratio in bottom gear gives a choice of six speeds. The box is mounted independently in the chassis and a short propellor shaft transfers the drive to the spiral bevel and epicyclic double-reduction rear axle.

Three-stage progressive springs carrying the rear axles are controlled by direct-acting shock absorbers. A two-way cock in the air-brake system enables the correct pressure for light and laden running conditions to be selected.

A new design of Spherub turntable facilitates location of the semi-trailer on the tractor. Its turntable, which is cast in steel, is carried at the sides on bonded semi-spherical rubber cushions; the lower metal elements of the bonded assemblies rest in a steel pressing attached to the chassis side members. Adequate freedom of fore-and-aft articulation is permitted by the rubber acting in shear, and cushioning is provided against all types of loading. Positive stops limit the deflection of the rubbers and also act as a safety device. The king post of the turntable has been made as a separate steel forging so that it can be replaced.

Particular attention was given to the design of the turntable to ensure that carriers which have been used with the companies earlier models of turntable mounting can be attached to the Spherub mounting.

The trailer which is 25 ft. long has a parallel link bogie designed to eliminate weight transfer during braking, and to improve the braking efficiency. A Panhard rod helps to eliminate twisting and side loading on the links and springs; spherical attachments at the ends of the springs prevent twisting of the springs. The central trunnion housing has been designed as an oil container to ensure that its bearings are always well lubricated. To remove the need for lubricating the Panhard-rod ends rubber mountings have been used.

DUMP TRUCK WITH 8 FORWARD GEARS

The dump truck illustrated below having a truck capacity of 5 cub. yd. and a heaped capacity of 6 cub. yd., is a four-wheel version of a larger vehicle made by Fodens, Limited, Sandbach, Cheshire. Designed originally for off-the-road duty, it has a width of 7 ft. 11 in., but bodies 7 ft. 6 in. wide can be made specially.

A 12-in. deep channel section is used for the two main members of the chassis. The cab, which is of the half type, sits on the frame and provides accommodation for the driver only. The engine casing at the nearside is detachable for inspection purposes, and when removed with the nearside wheel set on a left-hand lock the whole engine is easily accessible. To enable the operator to pass between the wheel and frame in order to approach the engine, a cycle-type nearside wing has been used.

The truck body has a floor of $\frac{1}{16}$-in. thick sheet steel and side plates of $\frac{1}{4}$-in. thick sheet reinforced with channel sections welded in position. An extension projecting over the cab protects the driver and engine from falling materials when loading is in progress. Two hydraulic cylinders mounted in cradles on the outside of the frame can raise the body in 12 sec. to an angle of 60 deg.

The power unit is normally a Foden FD4 two-stroke four-cylinder engine developing 84 brake horse-power, but provision is also made for fitting a 94 brake horse-power Gardner five-cylinder engine as an alternative. Three-point engine suspension has been used and a large radiator fan and oil cooler are mounted together on the front cross-member of the chassis frame.

The gearbox, which acts in conjunction with an epicyclic gear, has eight forward settings and two reverse and it is claimed that the vehicle is capable of climbing any gradient, providing wheel spin does not occur. To enable the epicyclic gear to be changed simultaneously with one in the main gearbox it has been provided with pre-selector control.

A short Hardy-Spicer propeller shaft links the gearbox with the worm drive to the 2-in. diameter rear-axle shafts. Integral-flange drive hubs, forged rear-wheel hubs and large roller races carry the wheels which are driven through a rear-axle reduction ratio of 8·33 to 1.

5/6-cub. yd. dump truck made by Fodens, Ltd.

Eight-wheeled platform-type lorry of 24-ft. overall length with modern-style cab. E.R.F. Ltd.

The front axles, which are of I-section, are made from high-tensile steel to withstand heavy-duty operation, and special axles of 2½-in. diameter and forged hubs are fitted.

Brakes are only fitted to the rear wheels when the vehicle is required for off-the-road operation, but in the event of highway running being necessary the fitting of front brakes is recommended. A hydraulic servo-mechanism operated by a pedal actuates the two leading-shoe brakes which are 16½ in. by 7 in. in size. For parking, a handbrake incorporating a compensating device between both wheels, and working on the multi-leverage principle, sets the shoes.

TRACTOR FOR MOUNTAINOUS COUNTRY

Another vehicle of large proportions is a new heavy-duty 66R six-wheeled tractor designed by E.R.F., Limited, Sandbach, Cheshire, for overseas use. A number of these vehicles will be used for long hauls in mountainous country at levels up to 5,500 ft. The power unit is a Rolls-Royce C.6NFR six-cylinder oil engine and develops 184 brake horse-power. The gross laden weight of the vehicle is 30 tons.

The chassis frame members have been pressed from ¾-in. thick plate and as a result are exceptionally rigid. Four cross-members join the longitudinals and fitted bolts are used. The overall length of the complete vehicle is 19 ft. 1 in. and the width 7 ft. 10½ in.

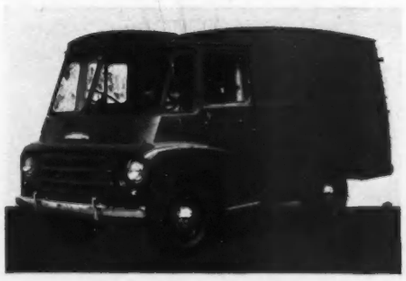
The engine and gearbox are supported at five points. The clutch is hydraulically-operated and the gearbox has a top ratio of 0·744 to 1. In bottom the ratio is 6·54 to 1. Both propeller shafts have Hardy-Spicer needle-bearing universal joints and drive overhead worm gears; with further reduction gearing fitted in the hubs of each axle, there is an overall reduction ratio of 8·64 to 1.

The tyre size on all wheels is 11·00 in. by 20 in. 14-ply and twin wheels are fitted on both driving axles. The wheel base is 10 ft. 9¼ in. and the ground clearance 10 in.

One of the other vehicles on this stand is the E.R.F. model 68G eight-wheeled lorry which is illustrated opposite. The modern treatment of the cab is typical of the present trend and is particularly pleasing to the eye. The large front screens provide an unobstructed view of the road ahead. A six-cylinder engine is fitted and the overall length is 24 ft.

Five-cwt. three-wheel delivery van. Reliant Engineering Co. (Tamworth), Ltd.

Five-cwt. Thames van. Ford Motor Co., Ltd.



Thirty-cwt. L.D.2 van with new-style radiator. Morris Commercial Cars, Ltd.

THREE-WHEEL DELIVERY VAN

A great many light vans have been introduced this year. Probably the smallest in the show is the 5-cwt. three-wheel vehicle produced by the Reliant Engineering Company (Tamworth), Limited, Tamworth, Staffordshire. The chassis longitudinals are pressed-steel sections and are joined by tubular-cross members. The body is constructed around a hardwood frame, and the side and roof panels are made of bonded fibreglass.

The engine has four cylinders of 2·2 in. bore and develops 14 brake horse-power. Its R.A.C. rating, however, is 7·5 h.p. Thermo-syphon radiator cooling is used, assisted by a fan driven by a belt from the engine pulley. The fuel system incorporates a Solex carburettor, and an A.C. petrol pump which is operated by the camshaft. A Borg and Beck clutch links the engine with a gearbox which gives four forward speeds and reverse.

Internal expanding brakes operated by a pedal act on all three wheels, but the handbrake applies the rear brakes only. Torsion-bar suspension is used for the front wheel and the rear wheels are hung from semi-elliptic springs mounted on rubber bushes; double-acting shock absorbers are provided to control the springing action. A stub axle carries the front wheel, which is mounted on a taper-roller bearing. The tyres on all three wheels are 4·50 in. by 14 in. and the wheels are of the pressed-steel design.

The laden weight of this vehicle, 15 cwt., allows for a full load of 6 cwt. to be carried at the relatively low fuel consumption of about 50 miles per gallon.

5-CWT. LIGHT VAN

The Ford Motor Company, Limited, Dagenham, arranged the introduction of their 5-cwt. Thames van, illustrated on this page, for the opening of the show. It has been designed to make use of a number of components fitted in the company's small cars and the front appearance is not unlike that of the Anglia saloon, as the illustration shows.

In keeping with present practice, the steel body is of welded integral construction to give the strength necessary for load carrying. The load space is accessible through two rear doors fitted with check arms, to retain them in the fully open position, and self-aligning hinges. Owing to the size and general arrangement of the vehicle, a loading height of as little as 23 in. unladen had been achieved.

The seat within the cab can be adjusted for position, the controls are conveniently placed and the instruments are grouped in a special housing built around the steering column. The smallness of the vehicle, it is claimed, will make driving through difficult traffic conditions less tiring. The clutch and brakes are hydraulically operated and there is independent front-wheel suspension.

The side-valve engine has four cylinders and a capacity of 1,172 c.c. The possible performance of this light van can be judged from the power to weight ratio of 66 lb. per brake horse-power.

30-CWT. VANS

In the medium-weight range Morris Commercial Cars, Limited, Adderley Park, Birmingham 8, have introduced a re-styled version of their L.D.1 and L.D.2 delivery vans. As can be seen from the illustration on this page the L.D.2 30-cwt. van now has a horizontal form of radiator grill and the headlamps, which are set in wings, are afforded full protection. Modification of the entrance has provided easier access for the driver. The engine used on the previous models is retained. It gives 46 brake horse-power at 3,250 r.p.m. and has a capacity of 2,190 c.c.

Vauxhall Motors, Limited, Luton, are exhibiting a recently introduced 30-cwt. model which is an adaptation of their 25-cwt. vehicle. It is fitted with stronger wheel studs and heavier rear springs. The steering has been improved by the provision of a flexible coupling between the steering box and the column, and the turning circle has been reduced from 52 ft. diameter to 46 ft. diameter, using standard tyres. Modifications have also been made to simplify the fitting of a heater.

Their 1-ton to 5-ton truck bodies are now being made with perfectly flat floors by the use of metal retaining strips between the boards set flush with the top surface. A lower bonnet line has been introduced giving improved driving vision and the side lamps have been mounted on top of the wings to reduce their vulnerability. The rear-brake pipes have been moved behind the rear axle from the front to protect them from stones which may be thrown up by the front wheels.

PLASTIC-COVERED VAN BODY

A further example of the use of plastics and aluminium in bodybuilding is to be seen on the stand of Dodge Bros. (Britain), Limited, Mortlake-road, Kew Gardens, Surrey, where a 600-cub. ft. van body built from a plastic bonded to a metal-mesh core and mounted on a 2-3 ton chassis is on show.

A light-alloy frame has been used and the plastic panels are riveted in position. The horizontal slats of the framing are placed about 6 in. apart and are arranged so as to run the full length of the body.

The roof is a one-piece moulding in glass-fibre bonded with Bakelite polyester resin. Incorporated in it are ribs of the same material. The roof is bolted to the main frame and although it is only ⅛ in. thick it is capable of withstanding heavy blows and can support the weight of a man. It is also resilient and leak proof.

The flooring is in a Melamine-surfaced laminate plastic sheet bonded to a special core and the underside is covered with laminated plastic. The Melamine is made with a non-slip diamond surface.

The front and rear wings of the vehicle are both made of glass-fibre bonded with Bakelite polyester resin.

A particular advantage gained from the use of plastic side panels apart from their weight-saving qualities is the fact that the outer panels can be made in the finished colour, in this case green. Furthermore, the insignia of the British Road Services, who have ordered this vehicle, is moulded in the surface of the material. Both these features are expected to result in a saving as repainting and signwriting, which is costly, will be unnecessary.

The vehicle was built by University Commercials and Coachwork, Limited, 99 Boston-road, London, W.7, for L. F. Dove, Limited, 111-115 Addiscombe-road, Croydon, who have been engaged over the past two years in developing the use of plastics in commercial vehicles. The plastic sheet used in the construction of this vehicle was made by Warerite, Limited, Ware.

To be continued

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"General Principle of the High-Voltage and Low-Voltage Networks that Supply the West End of London," by F. B. Evitt. West London Branch. Windsor Castle Hotel, 134 King-street, Hammersmith, W.6. Tues., Oct. 5, 7.30 p.m.
"The Association," by E. A. Bromfield. North London Branch. 667 Green Lanes, Harringay, N.4. Wed., Oct. 6, 7.45 p.m.
BOLTON
"Switchgear, Protection and Capacity," by C. Tyrrell. Bolton Branch. Balmoral Hotel, Bradshawgate, Bolton. Mon., Oct. 4, 7.30 p.m.
CROYDON
"Electrical Hazards and Electrical Safety," by Col. S. J. Emerson. South London Branch. Café Royal, North End, Croydon. Thurs., Oct. 7, 8 p.m.
ELTHAM
Discussion on "Atomic Research." South-East London Branch. Congregational Church, Court-road, Eltham. Tues., Oct. 5, 8 p.m.
ILFORD
Film Evening. North-East London Branch. Angel Hotel, Ilford. Mon., Oct. 4, 8 p.m.
LEEDS
"Electronics in Industry," by A. Williams. Leeds Branch. Great Northern Hotel, Leeds. Mon., Oct. 4, 7.30 p.m.
PRESTON
"Development of Alloys for Electric-Heating Elements," by H. Hodges. Preston Branch. Chamber of Commerce, 49A Fishergate, Preston. Wed., Oct. 6, 7.30 p.m.

British Institution of Radio Engineers

CARDIFF
"Design of Switching Circuits," by Professor Emrys Williams. Annual General Meeting. South Wales Section. Cardiff College of Technology, Cathays Park, Cardiff. Wed., Oct. 6, 6.30 p.m.
GLASGOW
Debate on "Does Industry Want Electronics?" Annual General Meeting. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Oct. 7, 6.30 p.m.
LIVERPOOL
"Liverpool University Cyclotron," by M. J. Moore. Followed by visit of inspection. Merseyside Section. Liverpool University Buildings, Liverpool, 1. Thurs., Oct. 7, 7 p.m.

Chemical Society

NOTTINGHAM
"Direct Hydroxylation of Organic Compounds," by Professor W. Bradley. The University, Nottingham. Thurs., Oct. 14, 4.45 p.m.

Illuminating Engineering Society

LONDON
Presidential Address on "Lighting and Electricity Supply," by E. C. Lennox. Royal Institution, 21 Albemarle-street, W.1. Tues., Oct. 12, 6 p.m.

Incorporated Plant Engineers

LONDON
"Controlled Air Conditions in Factories," by D. J. Hyam. London Branch. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Oct. 5, 7 p.m.
DUNDEE
Film: "Materials Handling." Dundee Branch. Mathers Hotel, Dundee. Mon., Oct. 11, 7.30 p.m.
EDINBURGH
"Trends in Industrial Instrumentation," by A. B. Dryburgh. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Oct. 5, 7 p.m.
PETERBOROUGH
"Plant Maintenance and Productivity," by R. A. Rogers. Peterborough Branch. Dujon Café, Market-place, Peterborough. Thurs., Oct. 7, 7.30 p.m.
SOUTHAMPTON
"The Control of Maximum Demand and Power Factor," by A. W. Ingram. Southampton Branch. Polygon Hotel, Southampton. Wed., Oct. 6, 7.30 p.m.

Institute of British Foundrymen

ACCRINGTON
"Production of Woodworking-Machinery Castings," by R. Higgins. Burnley Section. Accrington Grammar School, Blackburn-road, Accrington. Wed., Oct. 6, 7.30 p.m.
BRADFORD
"Pattern Making," by R. L. Simpson. West Riding of Yorkshire Branch. Technical College, Bradford. Sat., Oct. 9, 6.30 p.m.
SHEFFIELD
"Science Hand-in-Hand with Labour," by E. Ayres. Presidential Address. Sheffield Branch. Sheffield and Ecclesall Co-operative Society's Restaurant, Sheffield. Mon., Oct. 4, 7.15 p.m.
SLOUGH
"Aluminium Pattern Equipment," by D. H. Potts, with film. Slough Section. Offices, High Duty Alloys, Ltd., Slough. Tues., Oct. 5, 7.30 p.m.
SOUTHAMPTON
"Modern Trends in Pattern Making," by B. Levy. Southampton Section. Technical College, St. Mary's-street, Southampton. Sun., Oct. 10, 7.30 p.m.

Institute of Fuel

LONDON
"Special Study of Sulphur Removal and Recovery from Fuels." Conference. Institution of Mechanical Engineers, 1 Birdcage-walk, S.W.1. See ENGINEERING, August 27, page 278. Wed. and Thurs., Oct. 6 and 7, 10 a.m.
EDINBURGH
"Desulphurization of Coke-Oven Gas by Selective Quick Washing with Ammonia Solution and the Conversion of Hydrogen Sulphide to Sulphur, Sulphuric Acid or Ammonium Sulphate," by Dr. H. Bähr. Scottish Section. Joint Meeting with the Institute of Petroleum. North British Hotel, Edinburgh. Fri., Oct. 8, 7 p.m.
LEEDS
Chairman's Address, by S. J. Eardley. Yorkshire Section. Hotel Metropole, Leeds. Wed., Oct. 6, 2.30 p.m.
MIDDLESBROUGH
"Oil-Firing of Open-Hearth Steel Furnaces," by T. Chippindale and A. B. Pritchard. North-Eastern Section. Cleveland Institute, Middlesbrough. Mon., Oct. 11, 6.30 p.m.

Institute of Marine Engineers

LONDON
"Some Fuel-Injection Problems," by Dr. W. P. Mansfield. Tues., Oct. 12, 5.30 p.m.

Institute of Metals

LONDON
"Some Men of Metallurgy," by Dr. J. C. Chaston. London Local Section. Thurs., Oct. 7, 6.30 p.m.

Institute of Petroleum

EDINBURGH
"Desulphurization of Coke-Oven Gas by Selective Quick Washing with Ammonia Solution and the Conversion of Hydrogen Sulphide to Sulphur, Sulphuric Acid or Ammonium Sulphate," by Dr. H. Bähr. Joint Meeting with the Institute of Fuel. North British Hotel, Edinburgh. Fri., Oct. 8, 7 p.m.

Institute of Road Transport Engineers

LONDON
Annual General Meeting and Film Display. Royal Society of Arts, John Adam-street, Adelphi, W.C. 2. Thurs., Oct. 7, 6.30 p.m.
CAMBRIDGE
"Heavy-Duty Batteries for Commercial and Public-Service Vehicles," by C. P. Lockton. Eastern Centre. Lion Hotel, Cambridge. Wed., Oct. 6, 7 p.m.
GLASGOW
"The Design of Automotive Piston and Ring Assemblies," by L. Howell. Scottish Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Oct. 4, 7.30 p.m.
NOTTINGHAM
"Paint-Synthetic Resin Finishes and Wet-on-Wet Spraying," by C. Butler. East Midlands Centre. Mechanics' Institute, Nottingham. Thurs., Oct. 7, 7.30 p.m.
PRESTON
"Post-War Development in Brake Linings," by P. Tonge and M. Healey. North-West Centre. Victoria Station Hotel, Preston. Tues., Oct. 5, 7.30 p.m.

Institution of Chemical Engineers

CARDIFF
"Use of Glass in the Chemical Industry," by C. E. McEwen. South Wales Graduates' and Students' Section. University College of South Wales and Monmouthshire, Cathays Park, Cardiff. Wed., Oct. 6, 7 p.m.
MANCHESTER
"The Absorption of Carbon Dioxide in Liquid Spray," by F. Rumford. North-Western Branch. College of Technology, Manchester. Sat., Oct. 9, 3 p.m.

Institution of Electrical Engineers

LONDON
Presidential Address by J. Eccles. Thurs., Oct. 7, 5.30 p.m.
Chairman's Address on "The History of the Institution," by M. C. Cubitt. London Students' Section. Mon., Oct. 11, 6.30 p.m.
BIRMINGHAM
Chairman's Address by A. R. Blandford. Annual General Meeting and Conversazione. South Midland Centre. James Watt Memorial Institute, Birmingham. Mon., Oct. 4, 6 p.m.
BRISTOL
Chairman's Address by A. N. Irens. Western Centre. Offices of the South-Western Electricity Board, Colston-avenue, Bristol. Mon., Oct. 4, 6 p.m.
LEEDS
Chairman's Address by W. A. Crocker. North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Oct. 5, 6.30 p.m.
MANCHESTER
Chairman's Address by Professor E. Bradshaw. North-Western Centre. Engineers' Club, Albert-square, Manchester. Tues., Oct. 5, 6.30 p.m.
PORTSMOUTH
Chairman's Address by E. A. Logan. Southern Centre. College of Technology, Portsmouth. Wed., Oct. 6, 6.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
Presidential Address by Professor A. M. Robb. Tues., Oct. 5, 7.30 p.m.

Institution of Engineering Designers

NEWCASTLE-UPON-TYNE
"Engineering Costing and Estimating," by W. S. Shield. North-East Branch. 6 Higham-place, Newcastle-upon-Tyne. Mon., Oct. 4, 7.15 p.m.

Institution of Mechanical Engineers

BRIGHTON
"Patents for Inventions," by Major R. E. Tree. Southern Branch. Brighton Technical College, Brighton. Wed., Oct. 6, 7 p.m.
GLASGOW
"Nuclear Reactors and Power Production," by Sir Christopher Hinton. James Clayton Lecture. Scottish Branch. Royal Technical College, Glasgow. Thurs., Oct. 7, 7.30 p.m.
MANCHESTER
"Practical Training in Industry for the Graduate in Mechanical Engineering," by Kenneth R. Evans, H. W. Fulton, R. S. Medlock, D. P. Lant, and Professor J. A. Pope. North-Western Branch. Engineers' Club, Albert-square, Manchester. Thurs., Oct. 7, 6.45 p.m.
SWANSEA
Chairman's Address by Professor L. J. Kastner. South Wales Branch. Mackworth Hotel, Swansea. Tues, Oct. 5, 6 p.m.

Institution of Production Engineers

BRISTOL
"Works Study," by G. R. Burn. Western Graduate Section. Grand Hotel, Bristol. Mon., Oct. 4, 7.30 p.m.
HUDDERSFIELD
"Industrial Uses of 'Terylene' Polyester Fibre," by D. N. Marvin. Halifax and Halifax Graduate Section. George Hotel, Huddersfield. Mon., Oct. 4, 7.15 p.m.
MANCHESTER
"Rust: Its Prevention and Removal," by F. S. Bricknell. Manchester Graduate Section. College of Technology, Sackville-street, Manchester. Tues., Oct. 5, 7.15 p.m.
NEWCASTLE-UPON-TYNE
"Nickel Plating and Metal Finishing," by L. F. Prior. North-Eastern Graduate Section. Roadway House, 80 Oxford-street, Newcastle-upon-Tyne. Fri., Oct. 8, 7 p.m.
PETERBOROUGH
"Production of Domestic Appliances," by H. F. Adams. Peterborough Section. Campbell Hotel, Bridge-street, Peterborough. Tues., Oct. 5, 7.30 p.m.
"Plant Maintenance and Productivity," by R. A. Rogers. Peterborough Section. Dujon Café, Market-place, Peterborough. Thurs., Oct. 7, 7.30 p.m.
READING
"The Influence of the Production Engineer on Productivity," by Professor J. V. Connolly. Reading Section. Great Western Hotel, Reading. Thurs., Oct. 7, 7.30 p.m.
SOUTHAMPTON
"Surface Finish," by J. Halling. Southern Section. Polygon Hotel, Southampton. Thurs., Oct. 7, 7.15 p.m.

Institution of Structural Engineers

LONDON
Presidential Address by Dr. S. B. Hamilton. Thurs., Oct. 7, 6 p.m.
BELFAST
"Concrete as an Engineering Material," by J. Singleton-Green. Northern Ireland Branch. College of Technology, Belfast. Tues., Oct. 5, 6.45 p.m.

Junior Institution of Engineers

LONDON
"Oxygen-Breaking Apparatus, with Special Reference to Everest, 1953," by P. W. Fitt. Fri., Oct. 8, 7 p.m.
BIRMINGHAM
Annual General Meeting. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., Oct. 6, 7 p.m.
SHEFFIELD
Chairman's Address on "Furnace Construction," by F. Goldsbrough. Sheffield Section. Livesey Clegg House, Sheffield. Annual General Meeting. Mon., Oct. 11, 7.30 p.m.

Reinforced Concrete Association

BIRMINGHAM
Film Evening and Inauguration of the new Midland Counties Branch by the President of the Association. Birmingham and Midland Institute, Paradise-street, Birmingham. Tues., Oct. 5, 6 p.m.
EDINBURGH
Film Evening and Inauguration of the new Scottish Branch by the President of the Association. North British Hotel, Edinburgh. Tues., Oct. 12. 6.30 p.m.

Royal Statistical Society

LIVERPOOL
"Weights and Measures," by D. J. Desmond. Merseyside Industrial Applications Group. Liverpool Royal Institution, Colquitt-street, Liverpool, 1. Tues., Oct. 5, 7 p.m.
NEWPORT
"Statistical Methods Applied to a Study of Incentives," by L. T. Wilkins. South Wales Industrial Applications Group. Electricity Board's Showrooms, Newport. Wed., Oct. 6, 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Post-War Developments of Export Market," by Sir George Binney. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield, 3. Tues., Oct. 5, 7 p.m.

Society of Chemical Industry

LONDON
"Influence of Micro-Organisms on the Corrosion of Metals," by Dr. F. Wormwell and T. W. Farrer. Joint Meeting of Corrosion Group and Microbiology Group. Chemical Society, Burlington House, Piccadilly, W.1. Wed., Oct. 6, 6.30 p.m.

Society of Engineers

LONDON
"Influence of Murdock on the Modern World," by Marjorie L. Burgess. Geological Society, Burlington House, Piccadilly, W.1. Mon., Oct. 4, 5.30 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Engineering Designers, Grand Buildings, Trafalgar-square, London, W.C.2. (WHItehall 2489.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 15 Crescent-road, Sheffield, 7. (Sheffield 53674.)
Society of Chemical Industry, 56 Victoria-street, London, S.W.1. (VICtoria 5215.)
Society of Engineers, 17 Victoria-street, London, S.W.1. (ABBey 7244.)

Labour Notes

EXPORTS DEPENDENT ON HOME MARKET

Difficulties confronting Britain's overseas trade were referred to by Sir Harry Railing, M.I.E.E., chairman and joint managing director of the General Electric Company Limited, in his address to shareholders at the firm's annual general meeting in London on September 23.

Sir Harry said that, in the export market, Britain faced the hard fact that she had to meet competition from countries whose industries were taxed on a lower level and whose wage rates were much lower than her own. In Germany, for instance, wage rates in the engineering industry were some 25 per cent. lower than those in Britain.

It was essential, Sir Harry considered, that these differences should even themselves out eventually, as, otherwise, it would become increasingly difficult for this country to maintain even her present share of the world's markets and the living standards of her inhabitants, which were higher than in many other countries.

In the meantime, it was scarcely necessary to reiterate that, just as Britain's export prices, and therefore her exports, could not be kept at an adequate level without sufficient home demand, so prices in home markets could only remain at their present level if the volume of export business did not decline.

This fact, which was vital to Britain's economy, needed constant stressing. Compared, for instance, with the United States, which possessed an inland market for manufactured goods six times larger than that of this country, and a much smaller percentage of exported manufactures, Britain's economy was much more affected by variations in export.

DANGERS OF RISING LABOUR COSTS

In these circumstances, Sir Harry continued, it was essential that the difference in labour costs, which already existed between Britain and her foreign competitors, should not increase still further. With respect to many of Britain's products, labour costs, including the labour cost of raw materials produced at home, amounted to as much as 80 per cent. of the cost of the product.

As a result, every 5 per cent. advance in labour costs was likely to mean an increase of 4 per cent. in the total cost. That demonstrated the utter futility of the argument so very frequently heard that "the engineering industry could afford a general wage advance."

What might be possible in one section of the industry, where labour costs played only a small part, would be fatal in other sections. Broadly speaking, with taxation at its present high level, the cost of renewals of plant and equipment, existing hours of work and output per head, general wage advances could only be met either by reducing the remuneration on capital or curtailing the money available for research, plant modernisation, and new ventures.

Either course would be fatal ultimately, because it was not possible to retain a static economy. This country had to have an economy which was dynamic: one which enabled her to invest in progress and thus continually to create the additional assets required for any further division. If any country, or company, tried to reverse that process, its stability would suffer.

The conditions which were essential for the creation of fresh assets were well known. In the first place, it was essential that the nation should have the best possible weapons with which to fight, both now and in the future. That meant that the nation must be in a position to allocate sufficient manpower and sufficient capital for both short-term and long-term scientific and industrial research.

Secondly, the nation's industrial forces must not be weighed down by greater taxation, by shorter hours, or by dissipating too much strength on services behind the lines.

PROBLEMS OF STAFF IN TRANSPORT INDUSTRY

In an editorial dealing with staffing problems, a writer in the current issue of the *Transport and General Workers' Record* refers to a problem which is exercising the minds of many persons in numerous industries. He writes that in many parts of the country, considerable concern is being expressed, both by the employers and the membership, arising from the difficulty of attracting sufficient staff to the industry to enable schedule services to be operated. One of the features of full employment, he continues, is that workpeople now are in the position, should they so desire, of sampling different forms of work until they find the kind of employment which, to their mind, is most suitable for them. This opportunity to pick and choose is creating a problem for all industries, but particularly for the transport industry, where the changeover in staff and the cost involved in training new entrants involves a very heavy burden which has to be met out of revenue.

SEEKING A SOLUTION

After discussing, and dismissing, various suggestions tentatively put forward for creating an artificially high basic rate by the inclusion of payments for awkward spread-over duties, special "call-outs" and other activities, the writer states that if, as is generally accepted, output must be maintained, this can only be accomplished in outside industry by the introduction of more labour-saving machinery. In the transport industry where this is not possible he suggests that some re-allocation of work, together with perhaps some additional compensation for the awkward nature of his employment, would enable the transport employee to have a wage equal to the average paid in industry generally. The writer adds, in conclusion, that the problem of the shortage of staff is one which has been under careful review by the national committee of the Transport and General Workers' Union and that in examining the situation some reconsideration of policy may become necessary.

DIFFICULTIES FACING ENGINEERING EMPLOYERS

Speaking in Halifax last week, Mr. John A. Drake, chairman of the West Riding Group of the Engineering and Allied Employers' National Federation, laid stress on some problems which confronted engineering employers at the present time. He said that they were now faced with customers who were not begging for them to fulfil orders but were just prepared to meet them and discuss prices. Gone, moreover, were the days when they could tell their customers that they accepted their order subject to the price ruling at the date of delivery. It was now essential to quote firm prices, whatever the delivery date might be, and be prepared to accept the consequences. To be able to give a firm answer, the engineering manager must know what was likely to happen between his acceptance of the order and the delivery date. What was he going to do if, though a wage settlement had just been reached, he had a pretty good idea that another wage claim was "round the corner?" It was this instability which was worrying all engineering employers.

NEED FOR CERTAINTY AND STABILITY

The basis of a recent demand by trades unions for a revision of the wages structure, continued Mr. Drake, had been made on the grounds of increased profits and increased production. There had been a good deal of loose talk on profits recently. Calculations had been made on the gross profits of industry and no account had been taken of income tax dues, of reserves so necessary to the prudent and of the money to be "ploughed back" for re-equipment and maintenance so that firms could hold their own with their competitors overseas. As to distributed profits, rises in dividends among the large companies should not distract the beholder's gaze from the hundreds of small firms employing up to 300 workpeople which formed the majority of the firms in the Federation and which constituted the backbone of the engineering industry. They had only been paying their way.

There was, moreover, continual uncertainty concerning the cost of coal, gas, electricity and transport, namely uncertainty regarding the amount of the seemingly inevitable increase in the cost of these commodities. Again, complicated systems of accountancy and P.A.Y.E. all added to costs and fell particularly heavily on small and medium-sized firms.

In spite of difficulties, however, the engineering industry could beat all comers in technical skill and could meet the serious competition from Germany and Japan with their modern and newly-equipped factories if it could plan ahead with a degree of certainty.

RAILWAY WAGE TALKS

The hopes that substantial progress would be made at a meeting of the Railway Staff National Council (which consists of representatives of the British Transport Commission and the railway trades unions) held on September 24, to discuss a claim for a new minimum wage made by the Associated Society of Locomotive Engineers and Firemen, were not realised. Representatives of the National Union of Railwaymen raised an objection over a question of procedure, with the result that the negotiations suffered a distinct set-back. It appears, however, that the A.S.L.E.F. will formally submit their claim for discussion at a meeting of the Railway Staff Conference, the body which negotiates on such matters on behalf of the railway management.

In the afternoon of the same day, talks between the British Transport Commission and the N.U.R., adjourned on the previous day, were resumed.

DOCKERS' CHANGE OF UNIONS

Writing on behalf of the general council of the Trades Union Congress, Sir Vincent Tewson, general secretary of the T.U.C., has informed the National Amalgamated Stevedores and Dockers that it must cease enrolling docker-members of the Transport and General Workers' Union until the matter has been officially investigated.

At the time of writing little heed apparently has been taken of this request to stop recruiting members of the T. and G.W.U. On the contrary the movement away from this union and towards the N.A.S.D. appears to have become more pronounced. Speaking at a mass meeting of dockers, held in Hull on September 24, Mr. G. Hern, an official of the N.A.S.D., is reported to have stated that application had been made for 3,000 of their membership forms to be sent to the Port of Manchester.